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STUDIES IN *SACCHARUM SPONTANEUM*

THE GEOGRAPHICAL DISTRIBUTION OF SPIKELET LENGTH

By

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ONE of the important characters employed by Haeckel (1889) in distinguishing subspecies under *Saccharum spontaneum* is the absolute size of spicelets. According to him, subspecies *indicum* is characterised by spikelets 3 to 4 mms. long, while *aegyptiacum* possesses spikelets 4 to 6 mms. in length. A third subspecies *luzonicum* is described by him as having spikelets 4 mms. long. Panje (1933) found that among the thirteen variants which he studied from India, Burma and Indonesia, spikelet length showed much intergradation within the range, and that no demarcation between groups or clones was possible on this character. He observed that the form 'Sumatra' had the shortest spikelets, while the 'Dacca' and the 'Coimbatore' variants had spikelets about as long as any of the *aegyptiacum* group. Singh and Mukherjee (1952) from their studies on fourteen variants collected from South India stated that some of the variants had spikelets 4 to 5·8 mms. long, a range characteristic of subspecies *aegyptiacum*.

A world survey of floral characters of this species has now been carried out. In this survey, spikelet length has been intensively studied and the variations shown by it in relation to the geographical distribution and other characters are discussed in this paper.

Of the 217 variants studied, 173 were grown as clones under uniform conditions at Coimbatore and the samples are therefore strictly comparable *inter se*. But in the case of many of the African and South-east Asian forms, for want of locally-raised inflorescences, material collected from the original habitats of the variant has been used for comparisons. The spikelet length of each variant is the mean of 6 spikelets, systematically sampled from various parts of the inflorescence. Actually much larger samples were studied and after studying the variation, strictly comparable data alone were taken for purposes of this paper.

On the basis of the differences observed in the mean spikelet length, the following nine geographical areas arranged in the descending order of spikelet length are distinguished. The mean spikelet lengths in the different areas are diagrammatically represented in Fig. 1, and the distribution of the variants of different spikelet length is shown in Table I.

1. Nyasaland and Tanganyika
2. Mediterranean
3. Tropical Africa
4. Java, Celebes and China
5. Peninsular India
6. Philippines, New Guinea and Fiji
7. North India
8. Malaya and Sumatra
9. East Pakistan

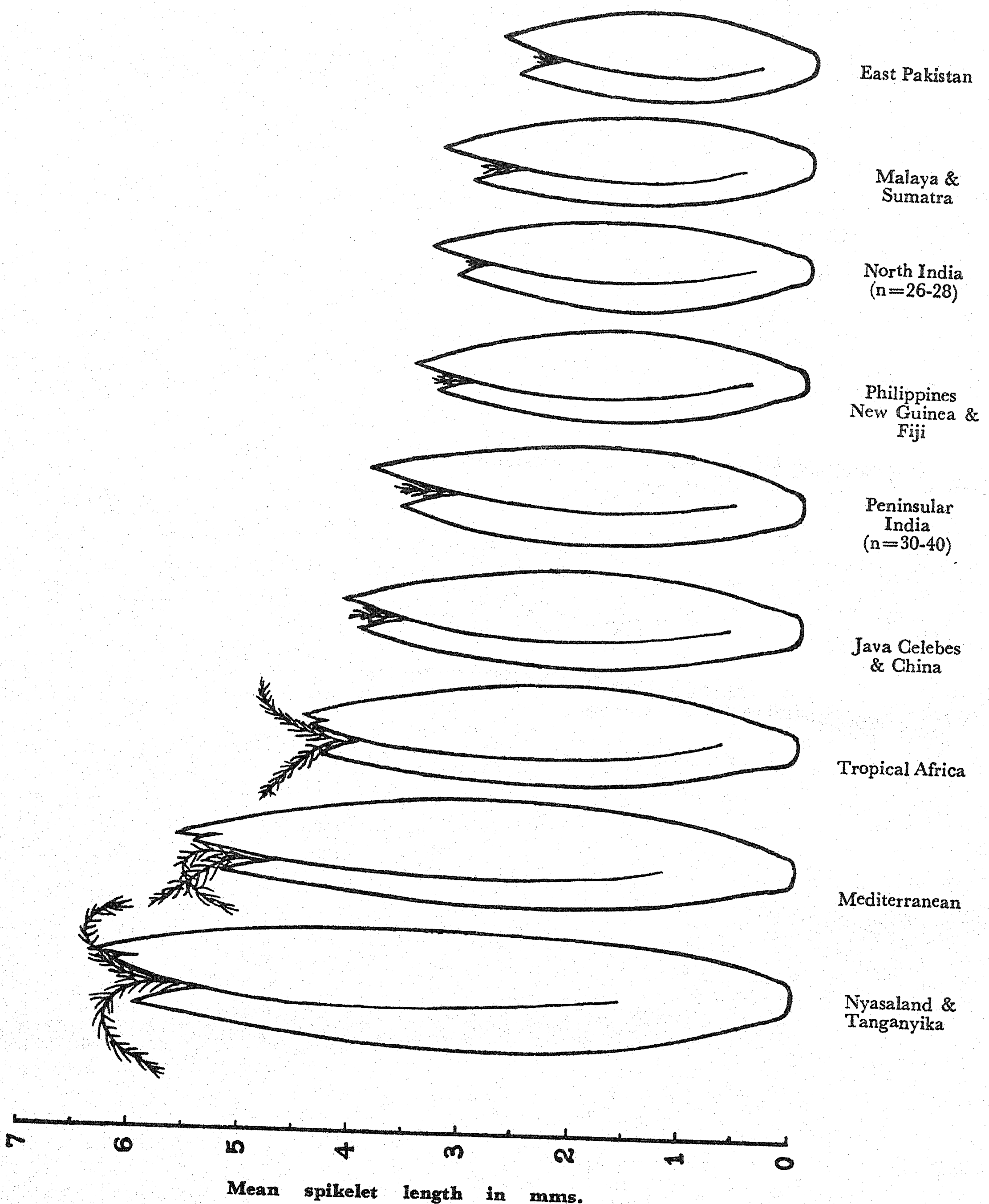
Nyasaland and Tanganyika.—This is one area in which the distribution of spikelet size is not known for certain, as only 2 specimens were available for study. But these specimens had exceptionally long spikelet, quite discontinuous with the population of the geographically adjacent Tropical African group. These have therefore been retained as a separated group. The mean spikelet length is 6·33 mms.

For the *Mediterranean* area, clones were available from Sicily, Southern Turkey and Lower and Upper Egypt, the number being 14. The mean spikelet length for this area is 5·54 mms. A form recently received from Israel also recorded 5·16 mms. which is well within the range of the Mediterranean group.

Tropical Africa for the purpose of this study has been taken as comprising Sudan, East Africa and West Africa. This somewhat huge area is represented in the collection by 18 clones. With the exception of one clone (US 4617) which is a seedling raised in the U.S.A. from seed imported from Uganda, all variants fall into a fairly compact group. The mean spikelet length is 4·40 mms.

These three areas constitute the Western division of the distribution area. They have as a whole longer spikelets than those of the eastern groups. Almost all of them have a bidentate lower glume, a character which is strikingly absent in other groups. Further, they are highly protogynous; the degree of protogyny exhibited sometimes extends to a time-interval of a week or more. Their panicles have the lowest callus hair length/spikelet length ratio. Their panicles are typically lanceolate with branches usually up to the second order

FIG. 1 Comparative mean spikelet lengths of *Saccharum spontaneum* in different geographical areas.



and rarely extending to the third order. A peculiarity which visibly distinguishes them from the rest is the characteristic droop of their racemes.

The *Java-Celebes-China* group, which for brevity may be referred to as the glagah-group ("glagah" being the Javanese name for spontaneum) is represented by 17 clones and has a mean spikelet length of 4·15 mms. The variants are mostly tall with broad blades and large arrows. The racemes are long and spread horizontally; the branching in most cases is only primary, rarely secondary. The panicles are

TABLE I

Frequency distribution of spikelet length in different geographical areas

Spikelet category	Length Class mm.	Number of clones of different spikelet lengths in: Nyasa-land Tanganyika	Mediterra-nean	Tropical Africa	Java, Celebes and China (Glagahs)	Peninsular India	Philippines, New Guinea and Fiji	North India	Malaya and Sumatra	East Pakistan
Very short	2·51–2·70	...	...	...	...	1	...	...	...	4
	2·71–2·90	...	...	...	...	1	...	2	...	2
	2·91–3·10	...	...	...	...	3	...	3	1	2
	3·11–3·30	...	...	...	...	4	...	2	3	1
Short	3·31–3·50	...	...	1	1	12	2	2	1	...
	3·51–3·70	...	...	...	1	19	1	4	1	...
	3·71–3·90	...	...	...	2	19	1	...	1	...
	3·91–4·10	...	...	4	3	22	...	2	1	...
	4·11–4·30	...	...	3	3	19	...	...	...	...
Medium	4·31–4·50	...	...	2	4	15	...	2	...	...
	4·51–4·70	...	...	3	3	5	...	...	...	...
	4·71–4·90	...	...	4	...	4	...	...	...	...
	4·91–5·10	...	3	1	...	2	...	...	...	...
	5·11–5·30	...	2	...	...	...	...	...	...	...
Long	5·31–5·50	...	1	...	...	...	...	...	...	...
	5·51–5·70	...	2	...	...	2	...	...	...	...
	5·71–5·90	1	4	...	...	...	...	...	...	...
	5·91–6·10	...	1	...	...	...	...	...	...	...
	6·11–6·30	...	1	...	...	...	...	...	...	...
Very long	6·31–6·50	...	...	...	...	...	...	...	...	...
	6·51–6·70	...	......	...	...	...	...	...	...	...
	6·71–6·90	1	...	...	...	...	...	...	...	...
	Totals	2	14	18	17	128	4	17	8	9
								Total		217

characterised by a violescent colour and the callus hairs are the longest among all the forms. It is probable that many of the Chinese forms originally came from Java. The form from Krakatau has recorded 60 haploid chromosomes (Babu, 1957). The Java and most Chinese forms have 56 haploid chromosomes while the Celebes and Formosan forms record lower numbers (32 to 48) (Parthasarathy and Subba Rao, 1946; Babu, 1957; Moriya, 1941 and Suzuki, 1940). The difference between the glagah group and the Tropical African group is not statistically significant, but the floral characters referred to above clearly distinguish them from each other. Because of the many characters which the Chinese (and Formosan) variants have in common with the Java-Celebes forms they have been included in one group.

The forms of the Indian subcontinent show a wide variation in spikelet length which ranges from 2·5 mms. to 5·7 mms. The curve of frequency distribution of the spikelet length however appears bimodal showing that there are at least two populations in India.

Since there are more of 'medium' and 'short' spikelets in the peninsula, while the northern parts have a predominance of 'short' and 'very short' spikelets, a geographical demarcation was attempted by

taking a number of dividing lines. The populations thus separated still showed bimodal distribution curves; a purely geographical distinction therefore came out as no more than a first approximation. Other characters of the inflorescence like callus hair length, callus hair/spikelet length ratio and certain qualitative characters like the presence or absence of starch and of rhizomes were correlated with spikelet size in order to see whether any of these could provide a phylogenetic basis for separating the spikelet populations; these were also found unsatisfactory. Ultimately when chromosome numbers were taken into account, some of the groups showed a common range which was fairly distinct from that of the others. The distribution according to chromosome numbers is shown in Table II.

TABLE II

Frequency distribution of spikelet length in relation to chromosome numbers in Indian forms

Spikelet Class mm.	Haploid chromosome numbers													
	20	24	25	26	27	28	30	31	32	33	35	36	38	40
2·51–2·70										1				
2·71–2·90 ...					2				1					
2·91–3·10 ...					2	1			2		1			
3·11–3·30 ...					1	1			3			1		
3·31–3·50 ...		1			1	1	2		8					2
3·51–3·70 ...	1			1	2	1	3		12	1				3
3·71–3·90 ...				1			2		15				1	1
3·91–4·10 ...	1					1	4	1	16					1
4·11–4·30 ...			1				3	1	12				2	1
4·31–4·50 ...					1	1			14					1
4·51–4·70 ...		1							5					
4·71–4·90 ...		1							4					
4·91–5·10 ...							1		1					
5·11–5·30 ...														
5·31–5·50 ...														
5·51–5·70 ...									2					
Total ...	2	3	1	2	9	6	15	2	95	2	1	1	3	9
											Total ...		151	

It will be seen from Table II that the chromosome group n=26 to 28 has a range of spikelet length 2·50 to 4·50 mms. whereas in the n=30 to 40 chromosome group spikelets range from 2·50 to 5·70 mms. The means are respectively 3·45 and 3·95 mms. There seems to be a factual basis for the division of Indian spontaneums on this basis, for the frequency distributions of the two populations are uni-modal and the difference in mean length is statistically significant. The 26-28 chromosome group has a geographical distribution almost entirely in North India while the other group occurs mostly in peninsular India; this group is referred to hereafter as the peninsular Indian group though some forms of it were from the submontane areas of Uttar Pradesh, Bihar, Nepal and Assam. The forms having n=20 to 25, though falling well within the range of n=30 to 40 have not been included with the latter since they are very few in number and their precise distribution is not certain. The 4 clones having 33-36 haploid chromosomes probably have to go with the 26-28 chromosome group, but tentatively they are retained with the 32-40 group, as they are regarded as aneuploids of the 32 group.

As many as 128 clones were studied for the *peninsular Indian* group which has a mean spikelet length of 3·95 mms. This is significantly lower than that of Tropical Africa but not than that of the glagah-group.

There are 2 forms in the peninsular India which record spikelet lengths of 5·68 mms. and 5·64 mms. respectively, which are exceptional for this group. These belong to the Gangavati taluq of Andhra Pradesh. In other respects these forms resemble the rest of the forms in peninsular India. The unusual length of their spikelets is unaccountable. There is another long-spikelet form, SES 91 (Coleroon Channel), collected from Cauvery delta in Tanjore (5·50 mms.). This form unlike the Gangavati clones, is exceptionally tall, but in other respects it also resembles other peninsular Indian forms. It has 48 haploid chromosomes and is the only form in the entire sub-continent having this number. It is considered by Rao (1957) to be a rare, naturally-arisen triploid mutant of the 32-chromosome form.

On the basis of spikelet size, the forms from Ceylon, Burma and Thailand can be placed in the same group as the peninsular Indian forms. For these areas, however, chromosome numbers are available only for a few and their inclusion in the peninsular Indian group is to that extent tentative. Some of the Burma forms have 32 to 34 haploid chromosomes and in plant form they resemble peninsular Indian forms.

Mention must be made of one clone collected from Ceylon (Kelaniya, near Colombo). This form was in our collection for 6 to 7 years, but failed to survive. It had spikelets 5·42 mms. long. It was tall and had broad blades, thick stalks and drooping racemes. It was highly protogynous and had whitish stigmatic papillae which unlike other forms from India never turned purple. The chromosome number was $n=64$. Except that it did not have bidentate glumes, it closely resembled the Tropican African forms, while the other clones from Ceylon showed similarity to peninsular Indian forms. Judging by these facts, Kelaniya SES 504 seems to be an introduction from Tropical Africa and should therefore be excluded from the peninsular Indian group into which the other Ceylonese variants fall.

The areas of (1) *Philippines, Fiji and New Guinea*, (2) *North India*, and (3) *Malaya-Sumatra* have an overall mean spikelet length of less than 3·50 mms. which is significantly lower than the spikelet lengths of all other groups. The differences between their individual means are not significant, but the forms of each area are recognisable on the basis of other characters.

There are 4 forms from the *Philippines, Fiji and New Guinea* group. These are tall with medium blades, possessing denser arrows with dark purple stigmatic papillae. These record chromosome numbers $n=38$ to 40. The spikelets of these fall under ' short category '. From the Philippine Islands, 9 clones with a spikelet length range of 3·18 to 4·10 mms. were available, but these were all raised from the fluff of one clone and accordingly a single reading viz. the mean alone (3·53 mms.) has been taken as representing the parent clone.

As said earlier, the Indian forms with chromosomes $n=26$ to 28 have been separated to form one group called *North Indian group*. For this group, 17 clones were available. These forms show variation in gross morphological characters from dwarf bushy form with wiry leaves to tall and foliaceous types. Forms with the shortest panicles occur in this area. The ratio of callus hairs/spikelet in these forms is higher than that of the Malay-Sumatra and Philippines-New Guinea-Fiji areas. The range of spikelet length is wide (2·71-4·50 mms.).

From Malay-Singapore and Sumatra, 8 forms have been available for study. The blades of these are very broad and are yellowish-green in colour. They have $n=30$ to 36 chromosomes. The thin form from Sumatra, though possessing $n=50$ chromosomes, has been included in this group by virtue of its possessing very short spikelets. Another form from Sumatra called ' Sumatra thick ' has certain peculiar features not met in other spontaneums. The glumes are highly coriaceous and the upper lemma is exerted much beyond the outer glumes and also has a median vein. It has 64 haploid chromosomes. In view of its doubtful origin, it has not been considered in the present study.

Lastly, *East Pakistan* is represented by 9 clones with chromosomes $n=26$ to 28 with one exception ($n=32$). These forms have consistently very short spikelets. The mean length 2·81 mms. is the shortest in the entire series, being about 2/5 of the length of the Nyasaland form. These clones are definitely different from the North Indian forms; unlike the latter, they are tall, foliaceous, have very large and dense arrows, the branching of racemes extending even up to the fourth order. They are all profuse flowerers at Coimbatore. These variants stand in a class by themselves, and form a separate short spikelet group.

Mention however has to be made of a variant collected earlier from this same area (Dacca). This form differs from the rest of the East Pakistan clones. It has 40 chromosomes and the spikelet length recorded for this variant is 4 mms. (Panje, 1933) which is about 1 mm. more than that of the other East Pakistan forms. Dacca has not flowered since, but a seedling of it, M 11292, has spikelet length of the same order and resembles its parent. Dacca is quite distinct from the East Pakistan group and possibly belongs to the $n=40$ chromosome stock which has been included in the peninsula group.

Table III shows the means and degree of variation in spikelet length met with in the nine areas described above. Most of the differences between the area means are statistically significant. One of the cases where the difference is not statistically significant is that between the Nyasaland and the

TABLE III

Mean spikelet length and the degree of variation in spikelet length in different areas

Geographical area	Number of variants examined	Mean spikelet length in mms.	Standard deviation ±	Standard error of the mean ±	Co-efficient of variation %
1. Nyasaland and Tanganyika	2	6·33	0·77	0·54	12·2
2. Mediterranean	14	5·54	0·40	0·11	7·2
3. Tropical Africa	18	4·40	0·43	0·10	9·8
4. Java, Celebes and China (Glagah) ...	17	4·15	0·34	0·08	8·2
5. Peninsular India	128	3·95	0·50	0·04	12·6
6. Philippines, Fiji and New Guinea ...	4	3·52	0·51	0.08	4·3
7. North India	17	3·45	0·49	0·12	14·2
8. Malaya and Sumatra	8	3·42	0·35	0·12	10·2
9. East Pakistan	9	2·81	0·23	0·08	8·2

Mediterranean groups; here the difference is of a high order and its non-significance is really due to the very small sample of material available from Nyasaland.

In other cases where the difference is neither large nor significant, the distinction between the concerned populations is supported by evidence on other floral characters. Such is the case with Tropical Africa as compared with the glagahs, with Philippines-cum-New Guinea, Malay-cum-Sumatra and North India as compared with one another. The division of the species into the nine different groups seems therefore to be well-based. The areas are shown in Fig. 2.

As already pointed out, the material compared belonged in all cases to clones. In order to see how far the variants bred true for their spikelet length, selfed progenies from some of the variants were examined. These were available in a limited number. They show that the means of the individuals of the progeny do not deviate much from those of their respective parents; it will be seen from Table IV that the standard errors, of the progeny-means are low, and the co-efficients of variation are as low as 3 to 6 per cent, as compared to 4-14 per cent for the means of the different geographical groups (vide Table III).

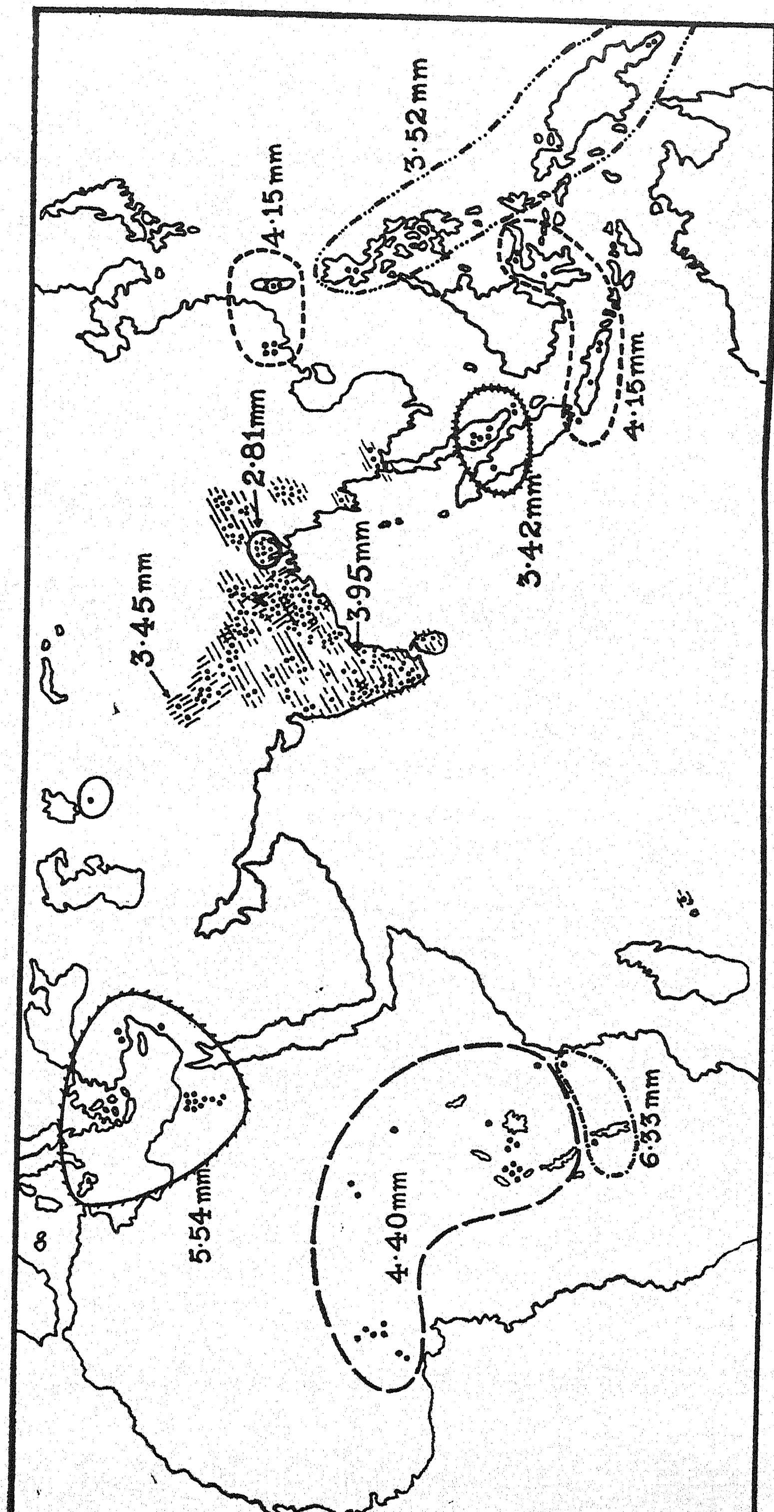
From outside of these nine areas, there are a few interesting variants. From Amu Darya in Turkmenistan 2 clones are available. These were raised from seed imported from that area. These have recorded a mean spikelet length well above 5 mms. thus falling well within the range of the Mediterranean group.

There is also a specimen from Mauritius. This has a mean spikelet length of 4·24 mms. It has affinities with the peninsular Indian forms in other characters also and is probably an introduction from peninsular India.

In conclusion it may be said that in the distribution area of the species, three broad zones are recognisable on the basis of spikelet length. That the three western groups, Mediterranean, Tropical Africa and Nyasaland apart from having long spikelets have many characters in common and probably form one major branch of the species has already been mentioned. Within this branch the three groups have undergone some divergence in respect of spikelet length; this divergence is partly supported by vegetative characters.

The area covered by the Peninsular Indian and of the glagah groups comprises a second zone of medium and short spikelets. Though the range in spikelet length of the glagah group falls within the range of the peninsular Indian group and the difference in spikelet length is not statistically significant, yet other differences both in vegetative and floral characters make the two groups quite distinct. The glagah group appears to have little affinity either with peninsular India or with any other South Asian or Pacific groups as regards floral characters.

Finally, the areas of Malay-Sumatra, Philippines-Fiji and New Guinea of the Pacific, North India and of East Pakistan come under the category of short and very short spikelets. That in the area of East Pakistan there is extreme expression of this short spikelets has been already indicated. While the East Pakistan and Philippine-New Guinea are tall and have some floral characters in common, the North Indian and North-west Indian forms are variable in habit, from dwarf bushy to tall and foliaceous forms.



Nyasaland and Tanganyika
Mediterranean
Tropical Africa
Java-Celebes and China
Peninsular India (n=30—40)
Philippines, New Guinea and Fiji
North India (n=26—28)
Malaya and Sumatra
East Pakistan

FIG. 2 Geographical distribution of spikelet length of *Saccharum spontaneum*

TABLE IV

Mean and variation in spikelet length of certain variants of S. spontaneum *and their progenies*

PARENTS				SELFED PROGENY				
S. No.	Variant	Collected from	Mean spikelet length (mms.)	No. of seedlings available	Mean spikelet length (mms.)	Standard deviation ±	Standard error of mean ±	Co-efficient of variation %
1.	SES 45	Satyamangalam, Madras ...	4·40	17	3·81	0·20	0·05	5·24
2.	SES 154B	Mahanadi, Orissa ...	3·63	3	3·88	0·12	0·07	3·09
3.	SES 186	Joshipur, Orissa ...	3·90	7	4·30	0·16	0·06	3·72
4.	SES 239	Raghunathpur, Bihar ...	4·03	7	4·09	0·23	0·09	5·62
5.	SES 505	Giza, Egypt	5·90	7	5·69	0·17	0·07	2·98
6.	Imp. 569	Djatiroto, Java	4·13	3	3·79	0·16	0·10	4·22
7.	28 NG 292	Port Moresby, New Guinea ...	3·73	1	3·79	...	...	...

The above study on the variation pattern forms a part of the analysis of variation in the species. Investigations on variation in other characters will be presented in future papers.

SUMMARY

(1) The variation observed in spikelet length and certain other floral characters of *Saccharum spontaneum* is partially correlated with geographical distribution. On the basis of this correlation, nine geographical areas have been distinguished.

(2) The African and the Mediterranean areas which constitute the Western division of the distribution area, in addition to having longest spikelets, possess a lower glume with a bidentate apex and the variants show a high degree of protogyny not found in forms of other areas.

(3) On the Indian subcontinent, the distinction between groups has been arrived at after taking into account chromosomes numbers in addition to spikelet length and geographical factors.

(4) The Java, Celebes and China group appears to have little affiinity with any other group.

(5) The area comprising (i) Philippines, Fiji and New Guinea, (ii) North India, (iii) Malaya-cum-Sumatra, and (iv) East Pakistan groups is characterised by short and very short spikelets. The extreme expression of short spikelets is seen in the forms of East Pakistan.

(6) The probable affinity of East Pakistan forms with Philippine forms has been indicated.

(7) Studies on selfed progeny in some of the variants have shown that the clones breed fairly true for spikelet length.

ACKNOWLEDGMENT

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A NOTE ON THE SCIENTIFIC AND COMMON NAMES OF SUGARCANE PESTS IN INDIA

By

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A LARGE number of insects are known to feed on and damage the sugarcane crop from the time of planting of the cane setts till harvest. So far no efforts have been made to compile a complete list of the insect fauna associated with sugarcane in India. Some work has been done on the systematic position of the Indian species of moth borers by Kapoor (1950) and on *Pyrilla* by Pruthi (1937), Qadri and Aziz (1942) and Mukerji and Prasad (1953) during the last two decades and the correct status of these major pests has been established. But in spite of this available information the research workers in the different States have been sticking to old, alternative or erroneous scientific names of the insects, e.g., *Chilo trypetes* Bisset. for the stem borer, *Bissetia steniellus* Hmpsn. locally known as Gurdaspur borer in Punjab and Dehradun borer in Uttar Pradesh. *Argyria sticticraspis* Hmpsn. which is really *Chiltoraea infuscatellus* Snell., and a shoot borer by habit, is known as stem borer in the North Indian sugarcane belt and as early shoot borer in the southern peninsula. Similarly *Pyrilla perpusilla* Wlk. is still being referred to as *Pyrilla aberrans* Kirby by some of the research workers, though it has long been established that the latter species does not occur in India. The other name *P. pusana* has also been proved to be a synonym of *P. perpusilla*. Besides, many of the major sugarcane pests are identified by their local names in various regional languages in the different parts of India, though the cultivators fail to exercise any discrimination between the different species of internal feeders like borers. In almost all the sugarcane growing States the different species of the top, stem and root borers are collectively known by only one local name.

This list of the common sugarcane insect pests (Tables I and II) has been prepared to remove the existing difficulties enumerated above and attempts have been made to give each of them a definite common English as well as a Hindi name for purposes of clarity. The list incorporates the latest and correct scientific names of the pests, their synonyms, including alternative or erroneous names, their present English names, the locality in which they have been recorded and new names coined to correctly distinguish each one from the others, duly supported by reasons for naming them so.

In addition, a list of the insects that have so far been recorded from sugarcane from time to time has also been appended. Most of these insects are casual visitors and naturally the information available about them is meagre. It is very likely that this list is incomplete for the reason that concerted efforts have never been made to record the insect fauna visiting sugarcane at different periods of the crop growth. Such information has its own importance not only in connection with the biological control work but also in view of the fact that some of these visitors may eventually change their habit and become a serious problem for sugarcane in course of time.

Every effort has been made to make the list as accurate and up-to-date as possible and a supplement will be published as and when more information becomes available.

Acknowledgments

Thanks are due to the State Directors of Agriculture and the Directors of Sugarcane Research Stations in India for supplying the information contained in this note from their respective areas. The author is also much indebted to Dr. K. B. Lal, Plant Protection Adviser to the Government of India, for his kind suggestions and criticism.

TABLE

List of major sugarcane

Sl. No.	Latest scientific name	Family and Order	Synonyms, alternative or erroneous names	Common English name	Distribution in different States
1.	*Scirpophaga nivella* F.	Pyralidae-Lepidoptera	*S. mosnostigma* Zell; *S. auriflua* Zell; *S. rhodoproctalis* Hmpsn; *S. intacta* Sn; *S. xanthogastrella* Wlk.	Top borer or top shoot borer	Punjab, U.P., Bihar, West Bengal, Andhra, Madhya Pradesh, Madras Rajasthan and Bombay
2.	*Bissetia steniellus* Hmpsn.	,, ,,	*Chilo trypetes* Bisset.	Gurdaspur borer or Dehradun borer	Punjab and U.P.
3.	*Chilotraea auricilia* Ddgn.	,, ,,	*Diatraea auricillia* Ddgn.	Stem borer	U.P. and Bihar
4.	*Chilotraea infuscatellus* Snell.	,, ,,	*Argyria sticticraspis* Hmpsn; *Diatraea sticticraspis* Hmpsn.	Stem borer, shoot borer or early shoot borer.	Punjab, U.P., Bihar, West Bengal, Andhra, Madhya Pradesh, Madras and Bombay
5.	*Chilo tumidicostalis* Hmpsn.	,, ,,	*Argyria tumidicostalis* Ddgn.	Stem borer	Bihar, Bengal and Assam
6.	*Chilo zonellus* Swinh.	,, ,,	*Chilo simplex* Butler	Stem borer	Punjab, U.P., Bihar and Bombay
7.	*Proceras indicus* Kapur	Pyralidae-Lepidoptera	*Diatraea venosata* Wlk.	Stem borer	U.P., Andhra, Madras, Mysore
8.	*Raphimatopus ablutella* Zell.	,, ,,	*Anerastia ablutella* Zell.	Stem borer	Punjab, U.P. and Bihar
9.	*Sesamia inferens* Wlk.	Agrotidae-Lepidoptera	*S. abliciliata* Sn. *Nonagria inferens* Slk.	Stem borer	U.P., Bihar and Madras
10.	*Emmalocera depressella* Swinh.	Pyralidae-Lepidoptera	*Papua depressella* Swinh. *Polyocha saccharellus* Ddgn.	Root borer	Punjab, U.P., Bihar, Bengal and Madhya Pradesh
11.	*Pyrilla perpusilla* Wlk.	Lophopinae-Hemiptera	*P. pusana* Dist. *P. aberrans* Kirby. (It does not occur in India).	*Pyrilla*; canefly (Madras)	Punjab, U.P., Bihar, Madhya Pradesh, Andhra, Madras and Bombay
12.	*Lachnosterna consanguinea* Blanch.	Scarabidae Coleoptera		Beetle borer	Bihar
13.	*Aleurolobus barodensis* Mask.	Aleurodidae-Hemiptera	*Aleurodes barodensis* Mask.	Whitefly, Mealywings, (Madras) Hardscales.	Punjab, U.P., Bihar, Assam, Madras, Bombay, Andhra and Madhya Pradesh
14.	*Aspidiotus glomeratus* Green	Coccidae-Hemiptera	*Targionia glomeratus* Green	Scale insect	Bihar and Madras
15.	*Macropes excavatus* Dist.	Lygaeidae-Hemiptera		Black bug	Punjab, U.P. and Bihar
16.	*Heiroglyphus banian* F.	Acrididae-Orthoptera			All States
17(i)	*Odontotermes obesus* Ramb.	Isoptera	*Termes obesus* Ramb.	Termites	U.P., Madras and Andhra
(ii)	*O. asmuthi*	,,		,,	
18.	*Microtermes obesi* Hlmgr.	,,	*M. anadi* Hlmgr.	,,	Bihar and Assam

I
pests of India

Local names	Recommended common English name	Recommended Hindi name	Reasons in support of recommended nomenclature
Punjabi—Kamad di choti di kiri; chhangwali kiri *Hindi*—Kansua, pihaka, ganne ki illi, ronti *Bengali*—Sadamajra, totapoka, nelipoka *Telegu*—Dolupurdu, purugulu and mogu purgu *Tamil*—Nuni puzhu *Marathi*—Usache shendyatil keed *Gujarati*—Sheradini tochkhoriyal, kunjado *Kannad*—Kabnina gari hula, suliyannu koreyuvahulu	Top borer	चोटी बेधक	By virtue of its habit of boring growing point in shoots and top internodes in canes.
Punjabi—Gurdaspuri garuan *Hindi*—Kansua	Gurdaspur borer	गुरदासपुरी बेधक	First recorded in Gurdaspur area in the Punjab.
Hindi—Kansua or pihaka	Stalk borer	गन्ना बेधक	Bores through all the internodes whether at the top, stem or near the root.
Punjabi—Kamad da garuan *Hindi*—Kansua, pihaka, illi *Bengali*—Totapoka, nelipoka *Telegu*—Dolupudu purugulu, mogi purgu *Tamil*—Kuruthu puzhu *Marathi*—Usache khodatil keed *Gujarati*—Sheradina gabhamarani iyal *Kannad*—Koreyanvahulu, kabnina detu kore yuva hula	Shoot borer	आंकुर बेधक	It is habitually a shoot borer.
Hindi—Kansua, pihaka *Bengali*—Tota poka, neli poka	Stem borer	स्तम्भ बेधक	Bores the stems of canes only.
Hindi—Kansua, pihaka	Maize borer	मक्के का बेधक	Habitually infests maize crop.
Hindi—Kansua *Telegu*—Dolupudu purugulu *Tamil*—Thandu puzhu	Internode borer	पोरी बेधक	By virtue of its habits.
	Green borer	हरा बेधक	Green colour of the larvae.
Hindi—Kansua, pihaka	Pink borer	गुलाबी बेधक	Pink colour of the larvae.
Hindi—Kansua, pihaka, ugra	Root borer	मूल बेधक	By virtue of its habits.
Punjabi—Kamad da ghora or gaddi *Hindi*— (U.P.)—Al, pharhka (M.P.)—Ganne ki makhi (V.P.)—Jharjari sunri *Telegu*—Dudekula purugu, rekkala purugu *Tamil*—Aeroplane punchi; *Marathi*—Usache panavaril tudtude *Gujarati*—Sherdina kudkudiyu	Pyrilla	पायरिला	It has grown very common with the cultivators.
Hindi—Garhra, pilua	White grub.	गड़रा	Owing to the colour of the grubs.
Punjabi—Kamad da tela *Hindi*—Cheinpa lahi *Assamese*—Chal pok *Telegu*—Aakupenu, nalla minnallulu *Marathi*—Pandhari mashi *Gujarati*—Safed makhi, dholi mashi *Kannad*—Belenona	Whitefly	गन्ने की सफेद मक्खी	Is white and looks like a fly.
	Scale insect		Locally known as such.
	Black bug	काला चिकटा	,, ,, ,,
Assamese—Faring *Telegu*—Midatha *Kannad*—Jitte	Rice grasshopper	धान का टिड्डा	,, ,, ,,
Punjabi—Seunk *Hindi*—Dimak; Dimaro, safed chinti *Bengali*—Uie *Tamil*—Karayan *Kannad*—Geddalu *Telegu*—Cheda purugu, chedalu	Termes	बड़ी दीमक	,, ,, ,,
Hindi—Dimak, diar *Assamese*—Uiin Paruah	Microtermes	छोटी दीमक	Locally known as such.

TABLE

List of minor sugarcane

Sl. No.	Latest scientific name	Family and Order	Synonyms, alternative or erroneous names	Common English name	Distribution in different States
1.	*Asamangulia cuspidata* Maulik	Hispidae-Coleoptera		Sugarcane hispa.	Punjab, U.P., Bihar and Madras
2.	*Saccharicoccus sacchari* Ckll.	Coccidae-Hemiptera	*Trionymus sacchari* Ckll.	Pink mealybug	U.P., Bihar, Madras and Bombay
3.	*Neomaskellia bergii* Sign.	Aleurodidae-Hemiptera	*Aleurodes bergii* Sign.	Whitefly, Mealywings, Soft scale.	Bihar, Madras and U.P.
4.	*Marasmia trapezalis* Guen.	Pyralidae-Lepidoptera	*M. similis* von Hedemann *Cnaphalocracis bifurcalis* Sn.	Leaf roller (Maize)	Bihar
5.	*Longuiunguis sacchari* Zhnt.	Aphididae-Hemiptera	*Aphis, Rhopalosiphum Sitha sacchari* Zehnt.	Aphids	Bihar and Madras
6.	*Bregmatothrips ramakrishnae* Bagn.	Thysanoptera		Thrips	Madras
7.	*Fulmekiola saccharicida* Ayyar and Margabandhu.	,,		Thrips	Bihar and Madras.
8.	*Procometis trochala* Meyr.	Pyralidae-Lepidoptera			Bihar
9.	*Philodonta modesta* Wse.	Hispidae-Coleoptera		Cane hispid	Madras
10.	*Tanymecus sciurus* F.	Curculionidae-Coleoptera.			Bihar
11.	*T. hispidus* Mshl.	,,			Bihar and Assam
12.	*Proutista moesta* Westw.	Derbidae-Hemiptera	*Assamia moesta* Westw.	Cane leafhopper	Madras
13.	*S. saccharicola* Takahashi.	Coccidae-Hemiptera	*Pseudococcus saccharicola*	Mealybug	Mysore
14.	*S. saccharifolli* Green	,, ,,	*Pseudococcus saccharifolli*	Mealybug	In all the States
15.	*Aclerda japonica* N.	,, ,,		Scale insect	Madras
16.	*Ripersia sacchari* Green	,, ,,		Mealybug	Assam and Andhra
17.	*Blissus gibbus* F.	Lygaeidae-Hemiptera		Blackbug	Punjab, U.P., and Bihar
18.	*H. nigrorepletus* Bol.	Acrididae-Orthoptera			All States
19.	*Anomala* sp.	Dynastidae-Coleoptera		Root grubs	Mysore
20.	*Oryctes rhinoceros* L.	,, ,,		Rhinoceros beetle	Madras
21.	*Paratetranychus indicus* Hirst.	Mite-Acarina		Sugarcane mites	Bihar, Madras, U.P., and Punjab

II

pests of India

Local names	Recommended common English name	Recommended Hindi name	Reasons in support of recommended nomenclature
Hindi—Babhani	Sugarcane hispa	बमनी	According to local Hindi name.
Telegu—Pindi nalli *Tamil*—Karumbu mavu puchi *Marathi*—Usavaril dhekanya, chiktya *Gujarati*—Sherdina chitka *Kannad*—Netti hula	Pink mealybug	गुलाबी चिकटिया	Locally known as such.
Hindi—Cheipa, lahi *Telegu*—Purgu	Leafbug	लाही	,, ,,
	Maize leaf roller	मक्के की पत्ती मोड़ इल्ली	It is a pest of maize.
Tamil—Karumbuasuni	Sugarcane aphids	गन्ने की एफिड	Locally known as such.
Tamil—Karumbupane	Sugarcane thrips	गन्ने की थ्रिपस	,, ,,
Tamil—Karumbupane	,, ,,		,, ,,
Hindi—Pihaka			
Tamil—Karmubu vandu	Cane hispid	वंड	According to local name.
Hindi—Babhani	Beetle borer	बेधक भृगं	According to classification of insects and its habits.
Hindi—Babhani	,, ,,		,, ,, ,,
Telegu—Nalla purgu *Tamil*—Karumbu thathu puchi	Leafbug	नल्ला	Locally known as such.
Kannad—Bili thigane	Mealybug	चिकटिया	,, ,, ,,
	,,		,, ,, ,,
Tamil—Krumbu mavu puchi	Scale insect	पूची	,, ,, ,,
Assamese—Kapathi Mowa pok *Telegu*—Pindi purgu	Mealybug	चिकटा	,, ,, ,,
Assamese—Faring *Telegu*—Midatha *Kannad*—Jitte	Rice grasshoppper	धान का टिड्डा	Locally known as such.
Kannad—Dumbimarigale	Root feeding grub	जड़ैला ग्रब	,, ,, ,,
Tamil—Kombuvandu	Rhinoceros beetle	काली भृगं	,, ,, ,,
...	Sugarcane mite	अष्टपदी	,, ,, ,,

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ELONGATION OF SUGARCANE IN RELATION TO SOIL MOISTURE

By

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UNDER the Co-ordinated Crop-Weather Scheme Sugarcane, growth observations are being recorded at Poona, on the sugarcane crop. Under another scheme for the development of methods and techniques for the determination of water requirement of crops, evapotranspiration of sugarcane was determined by growing sugarcane plants in big tanks (5′×5′×2·5′), kept flush with the ground inside the sugarcane crop so as to ensure that the microclimate experienced by the tank plants and the field crop was identical. In both cases P.O.J. 2878 was the variety under study. The mean daily values of evapotranspiration for the months of March to December, 1956 are given in Table I, as these may be of interest to research workers dealing with sugarcane. The evapotranspiration of sugarcane will be discussed in detail in a separate communication.

TABLE I

Evapotranspiration of sugarcane variety P.O.J. 2878

Period 1956	Mean daily evapotranspiration in inches (average of two pots)	Period 1956	Mean daily evapotranspiration in inches (average of two pots)
March 3 to March 15	0·111	August 17 to August 31 ...	0·328
March 16 to April 5	0·155	September 1 to September 21 ...	0·358
April 6 to April 26	0·263	September 22 to October 12 ...	0·193
April 27 to May 17	0·444	October 13 to November 1 ...	0·288
May 18 to June 16	0·563	November 2 to November 22 ...	0·184
June 17 to July 6	0·319	November 23 to December 13 ...	0·159
July 7 to July 28	0·177	December 14 to December 28 ...	0·196
July 29 to August 16	0·202		
		Total for March 3 December to 28 ...	82·76

Both in the tanks and the field, the setts were planted on January 17, 1956 and in both cases, germination was completed by about February 1, 1956. Periodical growth observations were recorded on the field crop by sampling and on all the canes of the tank plants. The observations on the field crop were recorded on 72 clumps (2 clumps in each of the 36 samples) while the observations on the tank plants were recorded on 21 clumps (12 in one tank and 9 in the other). The height of the tallest cane of each clump under observation from the surface of the ground to the junctura of the topmost fully open leaf was measured. The average height per cane, both in the case of the field crop and the tank plants, and the standard deviations (σ) are given in Table II from which it is evident that during the summer months the rate of elongation of the tank plants is greater than that of the field crop, but with the onset of rains (July onwards) the position is reversed and ultimately the field crop attained a greater height than the tank plants.

The field crop was grown under irrigation (about once in a fortnight) while the moisture percentage of the soil in the tank as maintained at a fairly high constant value (about 30 per cent at 6″ below the surface, increasing downwards). This appeared to suggest that the difference in the rates of elongation may be at least partly due to the difference in soil moisture.

Under the Crop-Weather Scheme, the moisture percentage of the soil in the sugarcane field is determined periodically at 6″, 12″ and 18″ below surface. According to Evans (1937), the vast majority of fibrous roots of sugarcane (which are most actively engaged in absorption) is present in the uppermost foot of soil. Therefore, soil moisture values for 6 and 12 inches depths only need be considered here. The values of soil

moisture in the sugarcane field, at these two depths, against dates are plotted in Fig. 1. The permanent wilting coefficient of moisture for the Poona soil, which is about 18 per cent, is shown as the line AB and the

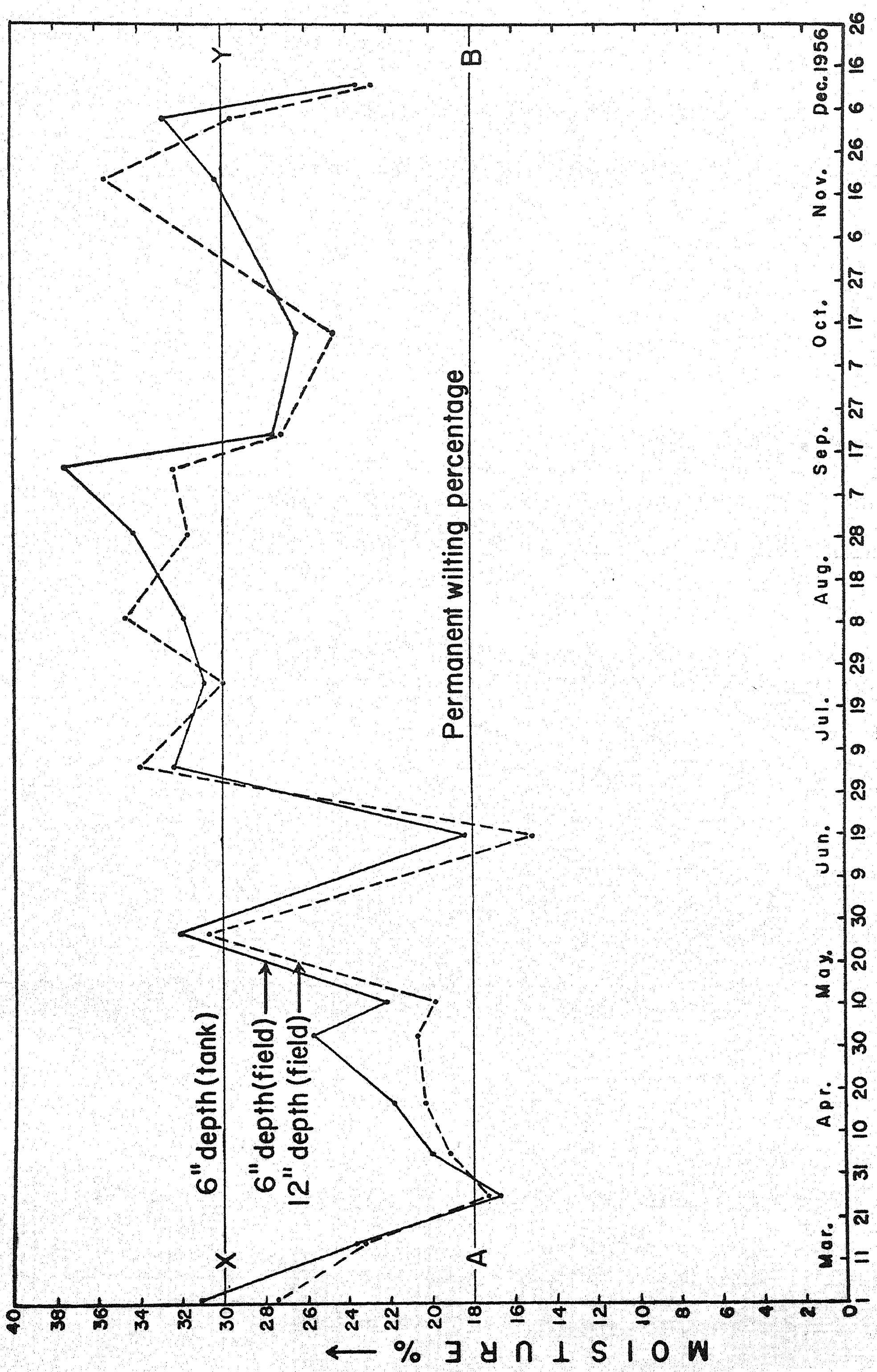

Fig. 1. MOISTURE % OF SOIL IN FIELD AND TANK.

moisture percentage of the soil in the tank which was maintained constantly at 30 per cent at 6″ below the surface increasing downward is shown by the line XY, at 30 per cent.

TABLE II

Height of cane of the field crop and the tank plants

Date 1956	Average height in cms.				Date 1956	Average height in cms.			
	Field Crop	Standard Deviation	Tank Plants	Standard Deviation		Field Deviation	Standard Crop	Tank Plants	Standard Deviation
March					*July*				
8	10·3	3·2	†		5	97·9	12·4	127·0	21·4
15	†		6·6	2·6	19	130·6	14·8	144·0	23·8
17	12·2	3·6	†		26	137·8	15·6	146·7	25·4
22	†		7·0	2·9	*August*				
24	10·2*	4·1	†		8	168·6	17·2	162·5	28·4
29	†		9·1	3·2	17	169·0	16·1	172·2	26·0
April					24	196·6	15·2	180·0	22·9
1	12·0	3·8	†		30	202·6	15·3	189·0	21·2
11	10·9*	4·5	15·0	4·7	*September*				
26	17·2	5·9	23·5	4·9	7	233·0	15·2	209·0	18·7
May					14	246·8	18·0	243·0	18·4
5	23·6	5·4	28·3	5·9	20	262·4	20·7	258·5	18·2
11	25·5	5·5	36·6	7·2	29	282·3	19·9	267·0	18·1
17	31·2	7·3	38·7	9·4	*October*				
24	33·9	8·8	†		12	317·3	18·5	305·6	18·3
June					19	319·8	22·4	312·7	17·8
1	46·0	14·9	70·0	14·2	26	333·0	26·3	317·7	17·2
8	52·9	13·2	†		*November*				
14	58·7	10·5	97·4	19·0	12	351·5	30·7	329·0	16·0
21	87·2	13·6	109·9	19·8	27	362·0	18·1	331·2	15·8
29	95·2	11·1	120·0	20·7	*December*				
					12	365·1	17·1	335·6	15·2
					28	364·0	15·4	340·0	14·8

*These obvious inconsistencies are due to the fact that for each day of observations the samples were selected afresh.
†Observations could not be recorded.

It is seen from Fig 1 that up to the end of June the moisture percentage of the soil in the field was lower than that in the tank, although it was higher than the permanent wilting percentage. As has been pointed out earlier, during the same period (up to end of June), the rate of elongation of the plants in the tank was definitely greater than in the case of the field crop. It appears therefore that soil moisture in the field, though greater than the permanent wilting percentage proved to be limiting for the elongation of the crop. Sweyzey and Wadsworth (1940) found that so long as soil moisture is above the permanent wilting percentage, elongation is not affected whether the soil is more or less moist. It would appear therefore that, strictly

speaking, the conclusion arrived at by Swezey and Wadsworth does not hold good under the climatic conditions at Poona where, during the summer months, the evaporating power of the atmosphere is extremely high.

It will be also seen from the values in Table I, that ultimately, even allowing for a margin of sampling error, the field crop is, definitely not shorter than the plants in the tank. According to Shaw (1937), there is no evidence that the growth of canes which have suffered from an earlier drought is accelerated when moisture becomes available, so that unrecoverable loss in tonnage is associated with each period when soil moisture falls below the permanent wilting percentage. It will be seen from Fig. 1 that the soil moisture did not fall below the permanent wilting percentage so that the crop in the field did not suffer any permanent loss of height even though the growth rate during the summer was somewhat limited by lower moisture content of the soil. Clements and others (1952) found that there is a check on the vegetative growth of sugarcane if soil moisture is not maintained near field capacity. This has been criticised by Kramer (1952) on the ground that the growth measurements of Clements and others (1952) were not made on the same day and therefore not under the same conditions of growth. Nevertheless, the growth measurements presented in this paper, made on the same day when all other growth conditions except soil moistures were identical for the tank plants and the field crop, lends support to the inference of Clements and others (1952). Of course, extremely useful results would have been obtained if the moisture shortness in the field could have been maintained even during the monsoon season (July-September). It is obvious though that it is practically impossible to do so and therefore any work on these lines can be done in pot cultures and not under field conditions.

In conclusion it may be added that the problem of elongation in relation to soil moisture has obviously important bearings on irrigation practice of the sugarcane crop and exhaustive work on the subject has been done in Hawaii. The object of this paper is to draw the attention of Indian workers to the fact that the conclusions arrived at by the workers at Hawaii have to be confirmed under Indian conditions before these are accepted and acted upon. The purpose of this article will be amply served if it helps to stimulate research in India on the important subject of effects of soil moisture in relation to weather conditions.

Summary

Elongation of sugarcane (i) crop in the field (irrigated once a fortnight), and (ii) plants grown in large containers (soil moisture maintained at a constant value of 30 per cent at 6″ below surface and increasing downwards) has been studied in relation to soil moisture. The findings of earlier workers that elongation is not affected unless the soil moisture falls below the permanent wilting percentage does not hold good, strictly, under the extremely dry conditions of Poona summer. However, there is no permanent decrease in the height of the crop if the soil moisture is maintained at a level higher than the permanent wilting percentage.

Acknowledgments

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ON THE COCCID *MELANASPIS GLOMERATA* GREEN ON SUGARCANE IN BIHAR

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COCCIDS, scale insects or mealy bugs as these are commonly known, fall in the category of minor sporadic pests of sugarcane, although in areas of severe infestation, losses caused to the crop are heavy. In the northern sugarcane belt, attack of the pest starts with the appearance of a few scales in the nodal region after the break of the monsoon from where it spreads to the whole of the cane stalk. They suck the juice from cane stalks with the result that the infested cane becames shrivelled; growth is stunted; internodes become much reduced in length and juice quality is variously impaired.

During the last six years a new coccid, *Melanaspis glomerata* Green (Coccidae) has been recorded on sugarcane in Bihar (1952, 1953) in widely dispersed areas like Pusa, Patna, Hassanpur and Harinagar and in certain cases the infestation has been very severe. The host range of the pest has included almost all varieties of sugarcane, as also wild saccharums, thereby affording an opportunity of studying the varietal behaviour of sugarcane to the attack of this pest.

The results (Table I) show wide variations in their susceptibility and resistance values.

TABLE I

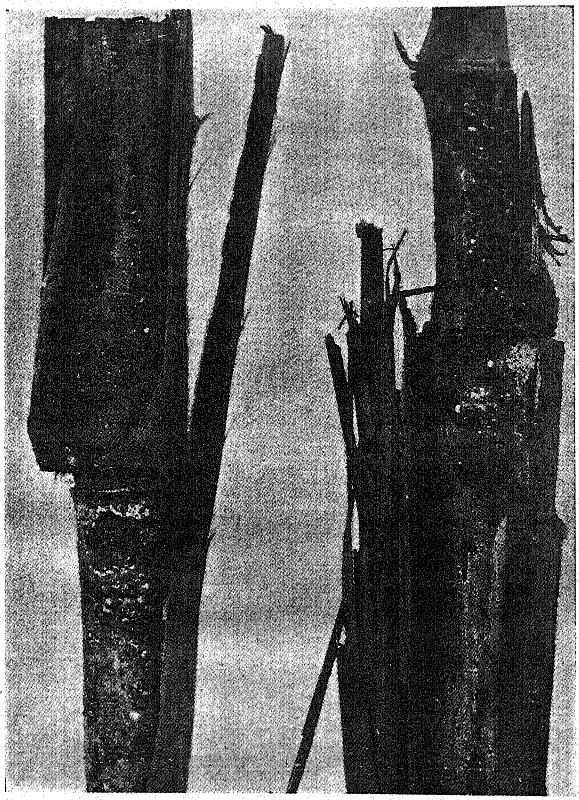
Sl. No.	Variety	Per cent canes affected	Per cent joints affected	Per cent length affected	Affected area per unit $\times 10^{-2}$	Remarks
1.	Co. 722 (R)	100	56·21	36·93	57·60	Highly susceptible
2.	X2756 (R)	100	39·58	18·45	32·03	Susceptible
3.	CoL 5 (R)	100	42·29	16·20	20·18	,,
4.	CoL 5 (R)	100	38·00	14·82	19·19	,,
5.	Co. 740 (R)	100	58·10	26·28	11·14	,,
6.	Co. 912 (R)	100	47·75	24·05	10·40	,,
7.	Co. 918 (R)	100	44·71	17·81	9·62	,,
8.	Co. 916 (R)	100	39·71	21·40	8·25	,,
9.	CoL 31 (R)	100	39·67	17·37	8·04	,,
10.	Co. 738 (R)	100	45.28	18.82	7·63	,,
11.	Co. 705 (R)	100	39·66	17·55	7·15	,,
12.	X 2557 (R)	100	48·54	17·52	6·42	Moderately susceptible
13.	Co. 717 (R)	100	49·70	15·12	5·50	,, ,,
14.	X 1891 (R)	100	39·67	11·88	5·31	,, ,,
15.	Co. 717 (R)	100	28·20	5·64	3·22	,, ,,
16.	X 2577 (R)	100	26·20	8·55	2·79	,, ,,
17.	Co. 644 (R)	100	27·98	7·86	2·30	,, ,,
18.	X 2632 (R)	100	32·03	4·97	1·95	,, ,,
19.	Co. 776 (R)	100	27·59	5·71	1·57	Resistant
20.	Co. 912 (P)	80	12·94	2·06	1·45	,,
21.	X 2394 (R)	100	27·18	3·72	1·30	,,
22.	X 2233 (R)	100	21·89	2·11	0·82	,,
23.	Co. 703 (R)	80	16·48	1·74	0·81	,,
24.	Co. 703 (P)	100	21·82	2·28	0·80	,,
25.	Co. 720 (R)	100	19·18	3·60	0·77	,,
26.	Co. 748 (P)	40	8·86	0·07	0·45	,,
27.	Co. 858 (P)	100	24·56	3·56	0·39	,,
28.	Co. 917 (P)	20	2·06	0·33	0·17	,,
29.	Co. 710 (R)	40	4·17	0·18	0·11	,,
30.	Co. 918 (R)	33	2·27	0·13	0·10	,,
31.	Co. 913 (P)	50	2·63	0·14	0·05	Highly resistant.
32.	Co. 776 (P)	20	1·49	0·04	0·01	,, ,,

(P)=Plant. (R)=Ratoon cane.

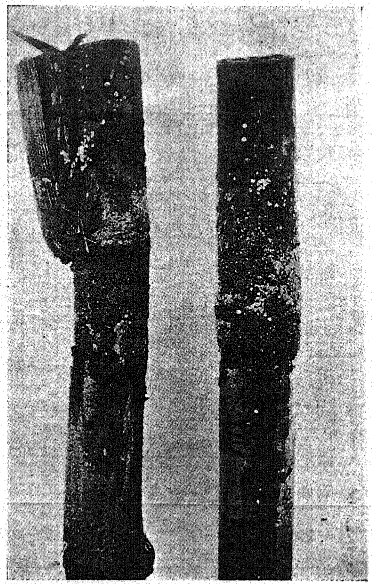
Thus Co. 722 was found to be highly susceptible as against Co. 913 and Co. 776, which were highly resistant. Ratoon crop seemed to suffer more infestation compared to plant crop.

Similarly in the survey carried out at Hassanpur, the varieties affected were B.O. 11, B.O. 24 and Co. 453 and to a lesser extent Co. 557, B.O. 22 and B.O. 25. Complete infestation studies on the former two showed infestation to the extent of 18·48 per cent, 18·70 per cent and 3·98 per cent on stalk, joint and length basis respectively in the case of B.O. 11 and 17·72 per cent, 5·39 per cent and 2·52 per cent in that of B.O. 24. Loss in sucrose per cent juice was of the order of 5·29 per cent and 0·55 per cent respectively. During 1956, a very severe infestation was noted in B.O. 11 at Pusa where the pest had invaded not only the cane stalk but also leaf-sheath and leaf lamina including its midrib (Fig. 1, 2 and 3). The whole length of affected cane stalks was covered with black dome-shaped scales giving thick incrustation on the rind. The distribution of scales on different parts of cane was studied (Table II) and results showed that this was heaviest on cane stalk followed by leaf-sheath.

FIG. 1. Sugarcane (B. O. 11) severely infested with scales (*Melanaspis glomerata*) The black dome-shaped scales lie thickly on the affected stalks.

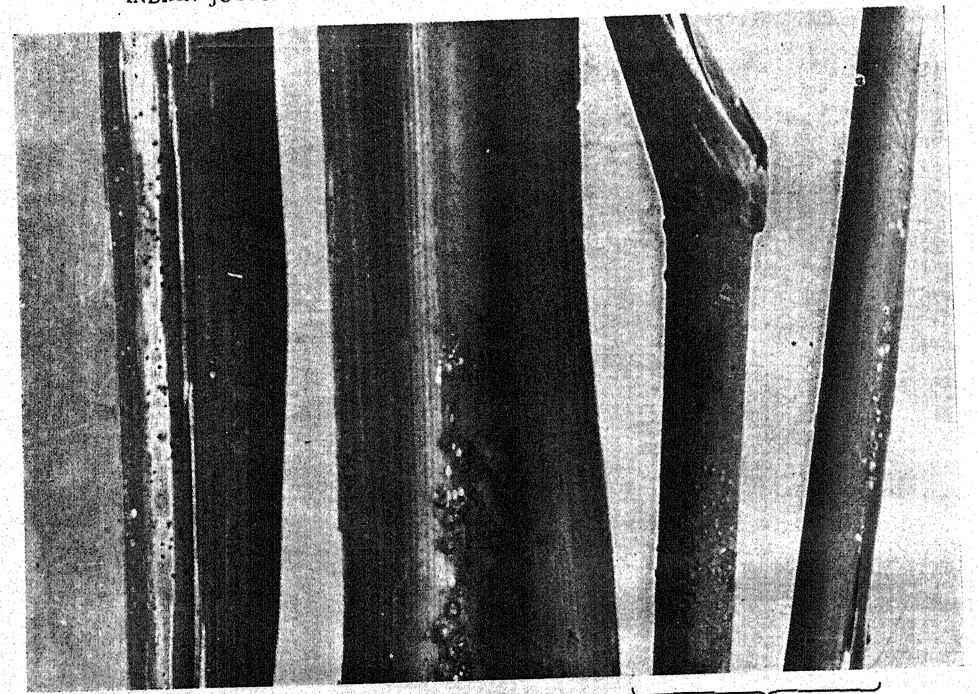


a



b

FIG. 2. (a & b) Enlarged view of infested joints showing thick incrustation in the affected portion.



a b c

FIG. 3 Infestation on (a) Leaf Midrib; (b) Leaf Lamina; and (c) Leaf Sheath.

TABLE II

Number of scales M. glomerata *Green on leaf-sheath, leaf-lamina and cane stalk*

Leaf-sheath				Leaf-Lamina				Cane-Stalk				Remarks
Length	Breadth	Total No. scales per leaf sheath	No. sq. inch	Length	Breadth	Total No. scales per leaf	No. sq. inch	Length	Circumference	Total No. scales per stalk	No. sq. inch	
Inches	Inches			Inch	Inch			Inch				
11·50	1·80	324	22·36	51·0	2·6	98	1·05	129·0	3·23	29,133	68·69	
13·50	1·60	171	11·31	55·0	2·3	37	0·23	96·0	3·13	25,398	84·88	
11·40	1·50	103	8·60	61·0	1·9	63	0·78	117·0	3·43	33,615	76·75	
13·00	1·70	441	28·51	62·0	2·0	29	0·33	111·0	3·13	30,327	87·64	
12·20	1·40	355	29·69	58·0	2·0	90	1·11	106·0	2·73	29,133	115·88	
	Grand Total ...		100·47				3·50				433·84	
	Average ...		20·08				0·70				86·77	
	S.E. ...		4·34				0·18				7·99	

The loss in weight occasioned to the crop was found to be 43 per cent and that in sucrose of juice to be 8·03 per cent, which was much higher than that in the case of Hassanpur. The affected setts gave very poor germination and this called for utmost care in the matter of seed selection in the affected areas.

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STUDIES ON THE INCIDENCE OF SUGARCANE BORERS

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Introduction

SUGARCANE is one of the most important industrial and commercial crops of the Madras State and is grown roughly over an area of 90,000 acres in the State. It is affected by a number of pests causing reduction in yield in all tracts. As such, knowledge of the important pests of sugarcane, their life history, incidence in relation to weather factors, control methods etc., is essential to undertake timely measures against the pests. The most important pests of the crop in South India are the borers viz., (1) the early shoot borer, *Chilotraea infuscatellus* S., (2) the internode borer, *Proceras indicus* K. and (3) the top shoot borer, *Scirpophaga* sp. A map showing the acreage under sugarcane in each district, the degree of infestation by the borers and the location of factories in Madras State is appended (Fig. 1).

Review of past work

The life history and habits of the borer pests have been worked out by several workers as cited by Gupta (1955), and a brief account is given below regarding the life history, habits of the pests and control methods tried in Madras State.

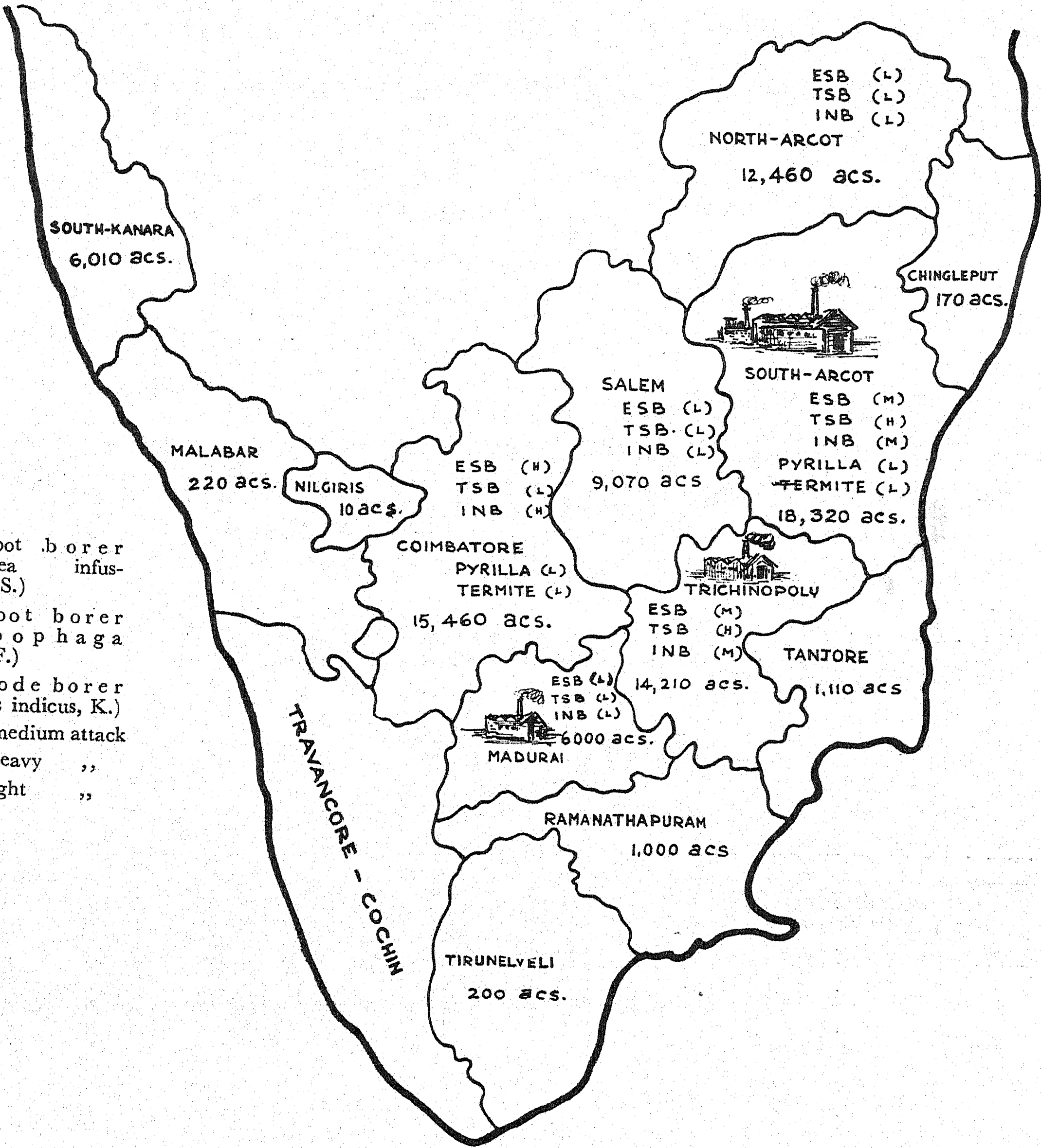
(1) *Chilotræa infuscatellus*.—It is mainly a pest of the young crop and makes its appearance along with the sprouting of the buds by April-May and continues to infest the crop till August. The caterpillars bore into the shoots causing the characteristic " dead hearts " and eventually their death. The scale-like eggs are laid in batches on the leaf surface. The egg period is from 3-4 days, the larval period about 30 days and the pupal period about 10 days. The maximum activity of the pest is noted to be in June at Coimbatore. The data collected on the seasonal incidence of the pest is given in Table I. Control measures were tried

Table I

Seasonal incidence of Chilotraea infuscatellus *S.*

Year	Period of occurrence	Range of average percentage of infestation	Range of average percentage of population	Remarks
1942–43	April to September	3·7 to 30·3	0·4 to 18·6	Peak infestation recorded in June
1943–44	May to September	0·1 to 6·8	0·1 to 2·6	,, ,, ,, ,,
1944–45	May to August	5·8 to 25·1	0·2 to 9·7	,, ,, ,, ,,
1945–46	May to August	0·5 to 14·2	0·2 to 5·8	,, ,, ,, ,,
1946–47	May to July	0·5 to 12·3	0·2 to 7·4	,, ,, ,, ,,
1947–48	April to July	1·1 to 21·0	0·2 to 4·5	,, ,, ,, ,,
1948–49	May to July	0·3 to 28·0	0·1 to 4·8	,, ,, ,, ,,
1949–50	May to August	0·9 to 19·3	0·1 to 6·7	,, ,, ,, ,,
1950–51	May to August	0·2 to 12·6	0·1 to 5·5	,, ,, ,, ,,
1951–52	May to harvest	3·6 to 22·1	0·1 to 5·3	,, ,, ,, ,,
1952–53	May to harvest	0·8 to 23·0	0·1 to 5·7	,, ,, ,, ,,
1953–54	May to harvest	0·2 to 23·1	0·1 to 5·1	,, ,, ,, ,,
1954–55	May to harvest	0·2 to 10·1	0·1 to 2·7	,, ,, ,, ,,

FIG. Outline Map of Madras State (prior to the Reorganization of States) showing important cane tracts and important cane pests in the areas.



ESB=Early shoot borer (Chilotraea infuscatellus, S.)

TSB=Top shoot borer Scirpophaga nivella, F.)

INB=Internode borer (Proceras indicus, K.)

M=Indicates medium attack

H= ,, heavy ,,

L= ,, light ,,

from 1926 onwards and steps like Dr. Kunhikannan's trash trap method, putting up light traps, fluosilicate dusting and using various other chemicals were without much success. Experiments conducted at Nellikuppam from 1947-50 have shown that two earthing ups given a month and two months after planting, definitely decreased the incidence of *Chilotraea*. Insecticidal trials using DDT and BHC conducted from 1947-50 have indicated that 0·25 per cent spraying of the chemical given four times at monthly intervals decreased the pest incidence. The data are given below:

Year		Total number of dead hearts per acre during the growing period		
		DDT plots	BHC plots	Control plots
1947–48	Percentage on control	52·9	70·3	100·0
1948–49	,,	64·9	80·9	100·0
1949–50	,,	67·8	82·2	100·0

As regards yield there was no increase in yield except in one year, but the reduction in infestation was statistically significant in all the three years. Of the two insecticides used, DDT showed better results.

(2) *Proceras indicus* K.—This attacks mainly well-formed canes and the injury is mostly confined to the internodes. The pest makes its appearance by July-August gradually increasing in virulence up to harvest stage. The eggs are deposited on both sides of leaves and occasionally on leaf sheaths and stems. The egg period is from 5 to 8 days, larval period from 28 to 38 days and pupal period from 9 to 10 days. The data collected regarding the seasonal incidence of the pest for the past 13 years is furnished in Table II. No practical method of controlling this pest has been evolved so far.

TABLE II

Seasonal incidence of proceras indicus *K.*

Year	Period of occurrence	Range of average percentage of infestation	Range of average percentage of population	Remarks
1942–43	July to harvest	0·3 to 36	0·3 to 8·3	Infestation during the later stages of crop.
1943–44	June to harvest	1·1 to 48·6	0·3 to 4·4	,, ,, ,, ,,
1944–45	July to August	0·1 to 43·0	0·1 to 4·0	,, ,, ,, ,,
1945–46	July to August	0·8 to 40·4	0·2 to 3·4	,, ,, ,, ,,
1946–47	July to January	1·4 to 36·2	0·1 to 2·7	,, ,, ,, ,,
1947–48	June till harvest	6·7 to 35·5	0·7 to 3·6	,, ,, ,, ,,
1948–49	June till harvest	1·1 to 30·3	0·2 to 2·7	,, ,, ,, ,,
1949–50	July to harvest	0·2 to 38·8	0·2 to 5·8	,, ,, ,, ,,
1950–51	August to February	0·1 to 21·3	0·1 to 3·0	,, ,, ,, ,,
1951–52	June to harvest	0·3 to 28·2	0·03 to 1·8	,, ,, ,, ,,
1952–53	May to harvest	0·8 to 27·3	0·03 to 2·7	,, ,, ,, ,,
1953–54	July to harvest	0·4 to 19·9	0·1 to 2·7	,, ,, ,, ,,
1954–55	July to harvest	0·7 to 32·0	0·4 to 4·5	,, ,, ,, ,,

(3) *Scirpophaga* sp.—This pest has been recorded as a minor pest at Coimbatore, though it is noted to be a more serious pest in other parts of Madras State, especially in South Arcot and Tiruchirapally districts. The pest attacks the early as well as the later stages of the crop and is therefore prevalent throughout the year. The eggs are laid on the lower surface of leaves in small batches and covered with reddish-brown hairs. The egg period lasts from 6 to 11 days, the larval period from 25 to 42 days and the pupal period from 12 to 21 days. The caterpillars bore into the central shoots and, reaching the growing point, arrest further growth. A " dead heart " is invariably formed due to their feeding on the heart leaves. The pest can be easily controlled by undertaking timely measures through mechanical means. The conspicuous white moths perching on the leaves, and the egg-masses may be regularly collected and destroyed. This operation may be conducted as soon as the adult moths are seen in the fields and should be continued at intervals up to the 6th or 7th month of the crop.

In Madras, studies on the sugarcane borers were started as early as 1926 by the Entomology Section. Investigations on insect pests of sugarcane in India were started on a coordinated basis in 1936. During the first five years, the research was mostly of an exploratory nature. In the second stage from 1942 onwards the work was carried out under two main heads viz. (1) control of the early shoot borer, by means of large scale breeding and liberation of the parasite, *Trichogramma evanescens minutum* Riley and (2) Biology and control of sugarcane pests by cultural, chemical and other methods. Both these studies were taken up at Coimbatore from 1942 onwards under the aegis of a scheme sanctioned by the Imperial (now Indian) Council of Agricultural Research. The second part of the work includes fundamental studies on the borer pests of sugarcane with reference to their incidence, nature and extent of damage, influence of weather factors such as minimum and maximum temperatures, etc., on the borer population, alternate host plants, natural enemies of the borers, varietal resistance etc. The work was conducted at Coimbatore utilising three varieties of sugarcane namely Co. 413, Co. 419 and Co. 421. The crop was planted every year in April-May in six replications in plots of 6·4 cents. Incidence and population of pests were recorded every three weeks from eleven-foot units in two rows selected at random in all the 18 plots. The observations were started after the occurrence of the first dead heart and continued till harvest. The macro and micro-climatic readings were taken daily at the crop site at 7·22 A.M. and 2·22 P.M. (I.S.T.). The result of the studies conducted for the past 13 years is given in the following paragraphs.

Analysis of the data

Exhaustive data on the three types of borers mentioned earlier with reference to the population in the life-period of the crop, varietal studies and influence of climatic factors, for a period of 13 years from 1942-43, have been collected along with data on the studies made on tillering in relation to mortality to see whether there is any adequate compensation by way of tillering for the mortality caused by the borers, The data collected with reference to each pest is given in detail separately.

Chilotraea infuscatellus.—The data gathered with regard to the pest incidence in relation to weather are presented in Table IV. The total population data as well as the average population data were considered separately with reference to each one of the weather factors.

The correlation worked out with the total population data indicates that the highest maximum temperature in the oviposition period is significantly and positively correlated with the total population. The correlation worked out with the average population data indicates that the incidence of the pest seems to be influenced by the amount of moisture present in the air. If the relative humidity is high, the incidence will be low.

The data indicates that Co. 413 seems to be highly susceptible and Co. 419 is fairly resistant. Co. 321 comes in between these two varieties with regard to the pest incidence. The data collected with reference to the three borers is given in Table III.

The life history of each individual plant (mother plants and tillers) was followed from the time of its emergence till harvest. The observations included germination counts, the date of emergence of mother plants, tillers and dead hearts as well as the mortality of shoots along with the causal agents. The observations at harvest included weight, length, number of internodes affected, and the juice analysis. Observations on emergence of tillers and deadhearts and mortality due to borers were made once in a fortnight in four rows of eleven feet unit lengths each marked out for the experiment in each replicated plot of the three varieties Co. 413, 419 and 421.

The data gave the following indications:

(1) Average percentage mortality of shoots due to early shoot borer infestation varied from 17 to 26 per cent. Co. 412 recorded the least mortality.

(2) Early shoot borer attack during the early stages of the crop was one of the main source of damage to the crop.

(3) The pest incidence in millable canes was negligible and ranged from 0·4 to 0·8 per cent.

(4) There is no adequate compensation due to high rate of mortality.

Proceras indicus K. the internode borer.—The data indicates that the incidence of this pest seems to be significantly influenced by meteorological factors like minimum temperature and wind velocity.

Co. 413 appears to have the maximum resistance to this pest. The total population data indicates that Co. 419 is slightly less susceptible than Co. 421. But the average population data and the data collected

during the peak period of infestation leaves practically nothing to choose between Co. 419 and Co. 421 with regard to their relative susceptibility to the incidence of the borer. But the value of Co. 413 as a resistant variety to the incidence of stem borer seems to be an uncontested fact.

The study on the correlation between the incidence of borer and damage caused by them and tillering in relation to mortality was conducted on the same lines as indicated earlier for the early shoot borer. The data showed that the pest infested 40 to 45 per cent of the canes. All the three varieties studied appear to be equally susceptible. The crop that came to harvest was infested to the extent of 45 per cent.

Scirpophaga sp., the top shoot borer.—If the average minimum temperature is really low during the period of occurrence of this borer the incidence of this pest is likely to be high in that particular year, mainly in the variety Co. 413.

Co. 413 seems to be highly susceptible to this borer. The total population data indicate that Co. 419 is slightly more resistant than Co. 421.

The damage by top borer was not more than two per cent. The infestation in millable canes at harvest was not heavy. Co. 413 recorded the heaviest attack of 6·9 per cent.

Discussion

The influence of meteorological elements on the incidence of borers is a very complex problem. Different factors of weather influence each borer differently and the indications revealed by the data have been already given.

Further, the relationship existing between the three types of borers were worked out. For this purpose nine correlations were worked out with the total population data of each borer in the entire life period of the crop. Each variety of cane was considered a separate unit. The findings from the correlations are detailed below.

(a) There seems to be no relationship between the total population of the early shoot borer and internode borer and also between the total population of the early shoot borer and top shoot borer.

(b) Between the total population of internode borer and top shoot borer there seems to be a definite positive and signifiant correlation particularly in the case of Co. 419. The inference is that if the incidence of internode borer happens to be severe in any particular year, it may safely be concluded that in that year, the incidence of top shoot borer will be equally severe.

From the inferences drawn regarding weather factors and from the total and as well as the average population data, the following main conclusions may be drawn.

(a) All the three borers are in one way or other influenced by weather conditions. High maximum temperature and low relative humidity seem to be conditions conducive for the heavy incidence of the early shoot borer, practically in all the three varieties of sugarcane.

(b) As far as internode borer is concerned, its incidence in Co. 421 only appears to be influenced by weather conditions.

(c) With regard to top shoot borer it will be seen that even the total population data are considerably lower than the total population data of the other two types of borers. However from the incidence of top shoot borer in Co. 413 it is seen that if the average minimum temperature is low, the incidence will be high.

Data on the meteorological factors and incidence of borers have been gathered for over a period of 13 years. The climatic conditions are not the same each year. Three different borers are concerned in the attack on sugarcane. From these diverse aspects and the inferences drawn as result of analysis of data gathered, it may safely be stated that Co. 419 appears to be the best variety of sugarcane from the point of view of its resistance to the incidence of different types of borers under the conditions obtaining at Coimbatore.

Acknowledgments

Our thanks are due to Sri C. Balasubramaniam, Agricultural Meteorologist, for kindly working out the statistical analysis and the correlation between weather factors and the incidence of the pests and to the various Government Entomologists and Assistant Entomologists who were in charge of the scheme from 1942 and collected the data on various aspects of the scheme. Our thanks are also due to the Indian Central Sugarcane Committee and the State Government who are financing the scheme on a 50:50 basis. We are also grateful to Sri K. P. Ananthanarayanan, Government Entomologist, for going through the manuscript and making valuable suggestions.

TABLE

Varietal resistance to

Variety	Name of borers	1942-43		1943-44		1944-45		1945-46		1946-47		1947-48	
		Per cent of infestation		Per cent of infestation		Per cent of infestation		Per cent of infestation		Per cent of infestation		Per cent of infestation	
		Max. during growing period.	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest
Co. 413	Ch.	32·6	1·9	8·6	9·3	26·1	2·1	22·3	2·5	17·6	0·2	23·7	0·9
	Pr.	39·8	53·1	50·9	45·6	42·0	41·6	33·3	47·6	33·9	25·0	37·9	64·7
	Sc.	8·1	1·9	3·7	1·2	13·1	0·4	3·9	1·2	5·0	0·7	7·3	8·3
Co. 419	Ch.	40·0	3·5	12·5	12·1	28·9	4·1	20·2	2·2	19·7	0·03	26·8	1·6
	Pr.	38·2	48·6	48·7	41·2	52·9	52·9	40·4	53·4	48·1	31·34	38·9	61·3
	Sc.	6·7	1·2	3·7	0·2	5·0	0·6	2·0	1·5	3·8	0·05	5·9	8·0
Co. 421	Ch.	31·1	3·0	6·1	10·2	30 6	2·8	14·8	2·4	20·5	0·2	27·3	0·9
	Pr.	33·9	45·7	45·9	45·1	38·8	45·6	52·9	39·3	36·7	23·6	35·7	64·3
	Sc.	5·3	1·4	2·2	0·2	5·4	0·1	3·7	0·5	5·9	0·4	5·5	5·2

TABLE

Weather factors in relation to peak

Period	No. of observa-tions	Maximum °F.	Minimum °F.	Average	Relative humidity		Rainfall in inches	Wind velocity	Per cent of
					Morning	Evening			Ch.
1	2	3	4	5	6	7	8	9	10
1942–43	7	86·1	73·8	79·9	79·1	57·7	0·26	8·0	18·4
1942–43	6	83·8	65·1	74·5	89·9	...	2·4	2·8	...
1943–44	6	84·9	73·7	79·3	77·6	64·3	1·7	8·2	3·1
1943–44	5	84 8	66·9	75·8	89·9	48·3	1·6	2·2	...
1944–45	6	89·1	73·5	81·3	77·4	53·3	1·4	5·2	15 8
1944–45	7	83·3	75·9	79·6	83·5	55·9	1·8	2·2	...
1945–46	5	86·8	73·4	80·4	78·3	59·4	0·72	5·6	12·6
1945–46	6	83·4	62·8	73·2	84·5	60·4	0·04	2·4	...
1946–47	6	88·4	73·1	80·8	81·4	64·0	1·48	6·0	10·7
1946–47	5	82·0	68·3	75·2	89·4	67·1	1·13	2·6	...
1947–48	4	87·7	74·5	81·1	82·4	59·7	0·64	5·1	20·5
1947–48	4	83·8	66·9	75·3	84·7	62·7	0·38	1·9	...
1948–49	3	87·1	73·5	80·3	79·3	59·1	0·53	5·0	27·7
1948–49	4	83·3	63·6	73·4	78·2	55·6	0·1	2·0	...
1949–50	3	85·7	72·7	79·2	77·6	63·2	1·0	2·8	18·1
1949–50	4	85·6	63·7	74·6	77·2	66·1	0·34	2·7	...
1950–51	3	87·9	72·7	80·7	74·2	53·3	1·06	6·7	14·0
1950–51	4	83·7	62·3	73·0	83·2	44·8	0·03	2·4	...
1951–52	5	88·3	72·3	80·3	79·4	54·7	1·23	4·5	17·4
1951–52	4	81·5	63 9	72·7	85·4	61·2	0·26	2·2	...
1952–53	5	90·1	74·3	82·2	79·6	55·1	0·31	4·5	20·9
1952–53	4	85·7	64·5	75·1	88·7	44 3	0·25	2·3	...
1953–54	4	86·4	72·6	80·6	78·1	57·2	1·99	3·0	21·9
1953–54	5	84·6	64·0	74·3	84·1	49·6	0·79	1·1	...
1954–55	6	86·0	71·5	78·7	82·9	64·1	1·09	3·8	8 9
1954–55	6	85·8	65·3	75·5	85·8	49·8	0·59	1·6	...

III

sugarcane borers (1942-55)

1948-49		1949-50		1950-51		1951-52		1952-53		1953-54		1954-55	
Per cent of infestation		Per cent of infestation		Per cent of infestation		Per cent of infestation		Per cent of infestation		Per cent of infestation		Per cent of infestation	
Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest	Max. during growing period	At harvest
31·4	0·5	29·0	0·4	16 8	0·1	28·5	1·6	26 4	1·1	30·6	5·3	12·1	1·0
27·4	50·7	35·3	51·6	16·5	37·6	28·9	34·5	21·3	37·8	17·5	28·3	28·3	40·2
10·7	11·1	18·3	14 1	3·4	4·2	11·2	4·3	7·9	11·1	15·4	0·7	16·1	6·8
33·7	0·7	22·3	0·9	16·5	0·03	22·7	4·1	21·5	0·6	26 6	1·4	13·8	2·2
37·2	49·7	58·0	53·3	28·6	45·3	32·8	39·8	38·5	41·2	25·8	32·8	40·6	50·0
8·4	9·6	13·0	9·5	2·3	0·8	12·6	6·0	9·0	7·1	9·9	4·0	12·1	6·3
32·4	0·4	26·0	0·4	18·4	...	20·5	2·2	26·5	1·2	22·3	1·1	11·9	1·4
44·8	45·1	45·1	59·9	32·3	43·5	23·9	45·8	29·6	41·5	20·9	30·7	33·5	46·0
10·0	10·7	10·7	6·6	2·3	2·3	11·8	3·7	7·9	5·6	11·4	3·2	13·0	3·5

IV

infestation of Chilotraea *and* Proceras

Per cent Infestation	Borer population		Per cent of infestation		Borer population		Per cent of infestation		Borer population	
Pr.	Ch.	Pr.	Ch.	Pr.	Ch.	Pr.	Ch.	Pr.	Ch.	Pr.
Co.	413			Co.	419			Co.	421	
11	12	13	14	15	16	17	18	19	20	21
...	4114	...	25·1	...	5599	...	24 0	...	4620	...
24·6	...	513	...	30·4	...	843	...	21·6	...	3190
...	1452	...	3·2	...	880	...	2·8	...	858	...
42·1	...	264	...	41·6	...	110	...	35·3	...	110
...	5500	...	14·6	...	2376	...	14·2	...	2728	...
37·8	...	110	...	44·5	...	264	...	32·9	...	220
...	1367	...	12·2	...	533	...	11·3	...	1200	...
23·7	...	278	...	28·8	...	288	...	30·7	...	167
...	1943	...	14·9	...	1503	...	14·2	...	1907	...
24·4	...	352	...	38·5	...	330	...	27·4	...	414
...	2393	...	23·8	...	1898	...	23·4	...	1953	...
32·4	...	1045	...	35·5	...	603	...	33·1	...	990
...	2420	...	31·9	...	2383	...	28·1	...	1953	...
24·3	...	440	...	33·8	...	523	...	30·7	...	605
...	2603	...	19·2	...	1797	...	22·3	...	2860	...
31·0	...	1403	...	42·5	...	1320	...	39·1	...	1788
...	2970	...	13·6	...	2310	...	14·3	...	3153	...
14·3	...	660	...	25·9	...	660	...	25·6	...	1155
...	3058	...	15·8	...	1914	...	16·4	...	2574	...
18·4	...	385	...	23·0	...	578	...	20·0	...	633
...	2090	...	15·6	...	1386	...	20·1	...	1166	...
19·1	...	330	...	23·2	...	770	...	25·6	...	495
...	2090	...	17·7	...	1540	...	17·3	...	1430	...
14·7	...	176	...	20·8	...	308	...	17·1	...	396
...	770	...	8·7	...	660	...	9·4	...	660	...
23·4	...	1008	...	35·8	...	880	...	26·6	...	733

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FIBRE IN SUGARCANE

I—A REVIEW

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INTRODUCTION

WHEN sugarcane is milled for *gur* or sugar manufacture, the juice extracted is processed into the desired form, utilising the by-product " bagasse " (also called megasse) as fuel. This bagasse consists of about 50 per cent moisture, the remaining half being " fibre ". Heat is produced by burning this fibre. Depending upon the varieties crushed, several sugar factories have been noted to have adequate bagasse to meet their full requirement of fuel. In certain factories, the bagasse obtained is found to be in excess of fuel requirement, and is being utilized for manufacture of paper boards, newsprint, and allied industrial products, whereas in other cases of fuel deficiency, wood and coal are used to supplement bagasse.

The nature of the fibre, which is the main component of bagasse, is known to vary with variety, cultural and climatic conditions, and also influence sugar recovery by inducing variations in milling performance.

In a particular factory in Andhra, an abnormal increase in the fibre content of cane was observed during the year 1956-57 as compared to previous years; since the same variety (Co. 419) was crushed in both seasons, it was felt that the marked increased in fibre value of cane might be due to climatic variations. This led the author to make a critical examination of the climatic and other factors responsible for this increase in fibre content of cane, with particular reference to some of the sugar factories in Andhra Pradesh. In this connection, a review of literature on fibre, which is rather meagre and scattered, has been compiled in order to bring together the available information for critical examination. The review has been made with special reference to formation, nature, milling performance, and calorific value of fibre.

This review is presented as the first part and the results of examination of the fibre in cane in respect of some of the factory zones over specific periods in relation to the respective climatic and other variations is proposed to be presented in a subsequent part.

FIBRE IN THE PHYSIOLOGY OF THE CANE PLANT

Fibre in sugarcane is defined by the International Society of Sugarcane Technologists as " the dry water—insoluble matter in cane " (Spencer and Meade, 1945). Fibre consists essentially of cellulose along with lignin and pentosan, and comparatively smaller amounts of fat, wax and mineral matter. The cellulose is incrustated with varying amounts of lignin, which is similar in composition to that of wood and which is mostly responsible for the hardness of fibre. The fibre does not occur in a strictly anhydrous state, but contains a certain quantity of water of hydration. This does not contain any dissolved sugar in contrast to the sugar-containing water in the parenchyma cells of the cane-stalk. The actual percentage, as also the physical texture, of cane fibre are reported to be primarily varietal characters. However, external factors like climate, fertilisation, and cultural treatments received by the cane have also an influence on the fibre.

The fibres (fibro-vascular bundles) of the rind of cane are heavier (meter weight) than those of the inner part of the stalk, due to larger amount of scelerenchymatous tissue and smaller amount of phloem and xylem. The meter weight of P.O.J. 2878, according to Dillewijn (1952), showed a gradual increase from the top towards the base. The tensile strength of the individual fibres is greater in P.O.J. 2967 than in P.O.J. 2878.

One external sign of the quality of the cane fibre is the colour of the stalk. Red and other dark-coloured canes are in general more difficult to tackle in the mills than green and light-coloured canes, despite the fact that the former contain less fibre per cent than the latter (Geerligs, 1924).

FIBRE IN DIFFERENT PARTS OF THE CANE STALK

The fibre content of different parts of a cane stalk varies considerably. The bottom portion called the " butt " contains highest amount of fibre. Kerr and co-workers (1937, 1938) studied in detail the variation in fibre in different parts of the cane stalk. The fibre in the middle was relatively uniform while that of top and bottom portions were higher. There was only a slight increase in fibre towards butt until

the lowest section was reached, when a sudden rise was recorded. According to these authors the fibre variations were thus confined virtually to the uppermost 3/12ths and lowest 1/12ths portions of the cane.

Even in a single internode of the stalk, the fibre varies depending on the amount of fibre-vascular bundles and the parenchyma cells present in different parts. Geerligs (1924) quoted elaborate figures from Winter and Beeson, to show that the nodes and rind of cane contain the largest percentage of fibre as compared to the inner pithy portion. This is more noticeable in older parts of the cane stalk than the younger ones. The hardest parts yield the least pure juice, and the inner softer portions give richer and purer juice. Physically, the fibre in the rind and node is woody, while the inner pith consists of thin-walled cells. The water-holding capacity of these parts is thus naturally different. As the chemical composition of fibre does not differ so widely, it appears that the differences in the physical condition mostly lead to technological differences in the fibre of cane varieties. Defining the nodal section of the stalk as the " portion one-half inch on either side of the leaf-sheath scar ", Kerr and Cassidy (1937) observed that this contained approximately two per cent higher fibre than the internode. From the standpoint of fibre content, the cane stalk may thus be regarded as " consisting of a soft interior portion made up of a low proportion of spongy, absorbent fibre, and a juice of a higher sugar content and purity, and of a hard outer portion containing a large portion of a resistant non-absorbent fibre and a juice of low sugar content and purity " (Geerligs, 1924).

Influence of Climate, Time of Planting, and type of Crop on Fibre in Cane

While the effects of climatic factors on both cane growth and sucrose accumulation have been studied in detail in many cane-growing countries, the influence of the same on fibre formation do not appear to have received much attention for study.

Extent of availability of soil moisture in the growing phase is noted to be one of the most important factors affecting fibre content of cane. Robertson (1932) recorded that in Java and Mauritius, drought at the beginning of the wet season, when the rate of cane growth was maximum, resulted in increase of fibre and acidity of cane. Fall-planted cane was generally reported to contain the smallest fibre content, and highest juice extraction in Cuba, while spring-planted and left-over cane showed higher fibre with lower extraction. According to Rosenfield (1955) " in all dry locations, unless irrigated, cane is smaller, more fibrous and sweeter than where moisture is ample and well distributed ". Deer (1921) stated that cane grown under drought conditions would contain a higher percentage of fibre " due to the restricted length of the internodes and the evaporation of water from the cane by increased transpiration ". According to Gairola (1955) cane under North Indian conditions had generally a lower pol and higher fibre content than under the tropical conditions of South India; further, cane with higher fibre was likely to deteriorate quicker after attaining maturity. In Queensland, cane harvested early in the season (July to August) contained lower fibre content (13·6 per cent on average) as compared to that harvested late (September-October) in the season (14·3 per cent on average). Immature cane was abnormally low in fibre content, at least during the growth period. As the newer growth approaches maturity, the fibre increased in amount, until it attained a value nearing that of the " butt "; this was attributed in part at least, to the drying-out effects of the attached green leaves during the dry spring months. Fibre determinations at different periods of harvesting season, indicated that the variation due to climatic conditions, as mostly limited to a substantial rise in the cane-fibre in the upper portion of the stalk with little change in lower part.

Periodical fibre determinations of cane varieties at Pusa (1938) showed that the stage of development of the plant had relation to the fibre content and juice extraction. The tops of canes, for instance, retained more juice than the bottoms, though the latter registered higher fibre content. Cornelison and Cooper (1941) investigated the changes in the cane fibre with age. They found that with advance in the age of the crop, there was greater deposition of lignin in and around the fibrovascular tissues, resulting in a hardening of the fibre up to the time of tasselling. After tasselling, however, much of the lignin was lost from the cell-walls, causing the bundles to become softer, and easier for penetration.

The differences in fibre content of ratoon and stand-over cane as compred to plant, were studied by Kerr and co-workers in Queensland (1937). For all the varieties studied, ratoon cane always showed higher values of fibre than plant cane, while stand-over cane had a substantially higher fibre content than either plant or ratoon. These authors attributed the above to the succulent nature of plant cane as compared to ratoon, while the stand-over cane was composed of a higher proportion of short, woody internodes formed during the winter months. The top portion showed the highest fibre for plant-cane stalks, while the butt gave the highest for ratoons. This was chiefly the effect of differential climatic conditions obtaining during the growth phase of the two types of crops, and the higher soil fertility of the plant cane areas.

The same authors also studied the effects of drying-out of stalks during storage, on the fibre content. There was a steady increase in fibre, a cane with initial fibre content of 10 per cent gaining in the same at average rate of 0·1 unit per day of storage. Actually the rate of loss of moisture was somewhat greater during

the first two days of storage. The studies also indicated more marked changes in fibre nearer the cut ends rather than the middle. The ratio of sucrose to fibre in cane was reported to remarkably increase when water was withheld three months prior to harvest in Hawaii (1956) and this was attributed in part to continued photosynthesis after growth has ceased.

Influence of Fertilization and Irrigation of Fibre Content

Borden (1944) studied the influence of nitrogen fertilization on the fibre content of cane; the effects were found to be almost the reverse of these on the moisture-content of the plant. Increased applications of nitrogen resulted in a decrease of fibre content. According to Hartt (1929) fertilization with potassium increases " cutinization ", with a decrease in the lignification resulting in a softer cane. According to Martin (1934) in soils deficient in boron, the lignified fibre of sugarcane cells was less, poorly developed and loosely arranged, than when the element was sufficient or in excess. Information regarding the influence of other fertilizer elements, as well as micro-nutrients on the formation of fibre in cane or its quality, does not appear to have been specifically dealt with in available literature.

Cane under irrigated conditions is reported to record lower fibre content than under unirrigated or drought conditions.

Technological characteristics of cane fibre

The role of fibre in the technology of sugar manufacture, both in influencing the milling performance of cane as well as the fuel value of bagasse, is discussed in the following pages.

Influence of Fibre on Milling Performance of Cane, Juice Extraction, and Sugar Recovery

The fibre portion of cane is a determining factor in facilitating milling and juice extraction. Both the quantity and the physical texture of fibre appear to contribute to its behaviour in the mills. Generally, canes of a higher fibre content yield bagasse with high fibre, which means that a hard cane yields a drier and a more exhausted bagasse than a soft one. It is probable that the fibre of a soft cane is more spongy and absorbs larger amount of juice than a hard one, (Geerligs, 1924). Such a texture of fibre in soft cane tends to reabsorb some small quantity of juice which is in contact with it even after expression, yielding ultimately a bagasse that will be more moist, retaining larger amount of juice. According to Geerligs (1924), thin canes, which usually contain a higher proportion of lignified material particularly in the rind, are harder to grind than thick ones.

From the above, it is evident that the percentage of fibre has a marked effect on juice extraction in the mills, the greater the fibre the less being usually the extraction for the same milling efficiency. It has been estimated that in Louisiana, the average extraction in sugar mills has fallen from 93·76 per cent to 89·17 per cent in a period of about ten years following an average increase in fibre from 10 per cent to 17 per cent, consequent on periodical introduction of new varieties, (Spencer and Meade, 1945). It has been computed (Anon., 1943), that an increase of 1·1 per cent in fibre content of cane was associated with a drop in normal extraction of 96° sugar by 0·2 per cent on cane. Deomano and Olelia (1954) recorded a lowering of sugar recovery with crushing of high-fibre canes in Philippines, while Locsin (1954) observed a decrease in Java ratio with increase in the fibre in cane fed to the mills. According to Arceneaux (1956), while using certain formulae for estimation of available sugar in cane it has to be remembered that the composition of normal juice (absolute juice) in relation to that of primary juice changed significantly with variation in fibre per cent of cane.

Foster (1956) considered the following three properties of cane fibre as important in regard to its technological behaviour in the mills:—

(i) The density of cane-fibre,

(ii) The quantity of juice in cells other than the " pith sugar-storage cells ", i.e. in the fibro-vascular bundle. This is the " fibro-vascular " water, which is comparatively sugar-free.

(iii) The quantity of adsorbed or "hygroscopic" water held in the cane-fibre under condition of varying temperature and humidity.

The average density of cane-fibre recorded by this author, using the pycnometer was 1·53. With regard to the " fibro-vascular " water, the author differentiated the thinner-walled xylem and phloem vessels, which acted as channels for translocation of sugars and the comparatively thicker " fibre cells " whose function was mainly to give strength and rigidity to the stalk. The fibro-vascular bundles and the vessels in a section of the internodes of variety Q·50 (excluding the nodes) were on average 5·3 per cent and 0·80 per cent of the

cross-sectional area. The amount of juice that could be expected from the fibro-vascular bundles was estimated to be 0·8 to 1·3 per cent, the brix of this being 0·8. The entire quantity of juice in the fibro-vascular bundles of the internodes might not exceed 3 per cent on weight of the cane; this might in part account for the "decreased concentration of the last expressed juice obtained from dry-milling".

On the other hand, the "hygroscopic water" in fibre, when kept at 100 per cent relative humidity, was estimated to be about 25 per cent (on dry weight of fibre) for the variety Q. 50. Foster (1956) indicated that the presence of hygroscopic water in cane could be proved by the absorption of water from sucrose solutions by "dry, sugar-free fibre".

Fibre in relation to "Slippage" of Cane in the Mills

Ramanujam (1956) made a detailed investigation of technological properties of fibre of a number of Indian cane varieties with particular reference to their behaviour in the mills. He also studied the probable causes responsible for the "slippage" in the mills of a number of B.O. canes, that are popular in North Bihar, resulting in milling interruption, labour wastages and increased maceration. Higher lignification of scelerenchyma in the periphery, compact and highly lignified cells of the rind in the lower regions particularly in varieties with smaller number of vascular bundles appeared to cause brittleness in the bagasse structure, and, with lack of cohesion in the bagasse blanket, were said to induce "slippage" in the mills. The variety B.O. 11 was an example of this class. He concluded that varieties (like B.O. 11) with a larger number of long hexagonal subepidermal cells might cause slippage.

Since the cell-wall tended to elongate and put up resistance at every phase of crushing, thus causing slippage, the author opined that the higher the cell-wall area, the greater the slippage was likely to be. Further, in the case of varieties like Co. 453, though the cells were squarish, they were bigger and broader, thereby decreasing the number of cells per unit volume. This also led to less resistance with a tendency for slippage in the mills. Finally the author believed that a combination of a number of anatomical characters of a cane variety, that influenced the nature of fibre, would determine its behaviour in the mills.

Stockhill (1956) reported that better preparation of cane prior to milling gave finer bagasse ultimately, and that the pol in bagasse containing coarser bits was far higher than that consisting of finer particles. In a study on the behaviour of low-fibre cane towards milling in the Philippines, Sverte (1956) observed that bagasse from such cane was largely powdery like "saw-dust" resulting in difficulty of extraction on account of the pasty nature of the mass. Hence the degree of preliminary preparation of cane, though indispensable should not be carried beyond a certain limit, and it was not the "intensity but the quality of shredding" that was important.

Heat Value of Fibre (bagasse)

Since the ultimate constituents of bagasse of any origin are almost the same, its heat of combustion (calorific value in B.T.U. per lb. bagasse) would vary within narrow limits. Deerr (1921) quotes a number of authors to prove this. He attributed even minor differences in heat-generating power to the variation in the relative amounts of rind tissue and pith tissue, the former always having a higher calorific value. A denser bagasse also tended to be richer, had greater cellulose content and recorded a higher calorific value. According to Geerligs (1924 the calorific value of fibre of Java canes varied from 7862 to 8325 B.T.U. per lb. of dry fibre. The calorific value of Louisiana cane fibre was about 8325 B.T.U. and that of Cuba cane about 8435 B.T.U. per lb.

Bhattacharya (1953) reported on the calorific value of fibre of a few cane varieties in India. The variety P.O.J. 2878. (plant cane) showed the highest value of 8401 B.T.U. per lb. followed by adsali crop of the same variety which recorded 8285 units; the popular variety of this state (Andhra Pradesh), Co. 419 (plant cane) recorded a fibre calorific value of about 8100-8200 units per pound.

According to Geerligs (1924), the temperature of combustion of bagasse is a very important factor in sugar factory technology. Different interfering factors like insufficient or excess of the air draft, excessive moisture in bagasse resulting from improper crushing or imbibition etc., tend to lower the ultimate heat of combustion as certain organic compounds tend to simply distil over without burning and undergoing oxidation.

Deerr (1921) compared bagasse favourably with ordinary wood in respect of calorific value and observed that from four to five tons of bagasse would equal a ton of average coal.

Jagjit Singh (1956) reviewed recently the work done in the Fuel Economy scheme conducted at the National Sugar Institute, Kanpur, along with a survey of the steam generation and utilisation in 45 sugar factories, in India. He suggested recommendations for achieving self-sufficiency by factories in respect of

fuel economy by using the bagasse furnace and "gilled-tube economisers" designed by the National Sugar Institute, Kanpur.

Ramanujam (1956) made a detailed study of the reasons for the poorer "steam-raising" quality of the variety Co. 419 as compared to Co. 453, B.O. 11, B.O. 24, and BHURLI. He opined that varietal differences in respect of the calorific value of bagasse were mainly dependent on the compactness of its structure; bagasse containing less of "fibrous dust" exhibited higher steaming quality. The ratio of the parenchyma cells which are bigger, to the smaller and more lignified cells in the rind was an important factor in determining the quality of "dust" in bagasse; this ratio for Co. 419 was 1:19, whereas for Co. 453 and Co. 513, the ratios were 7:10 and 1:6 respectively.

Summary

The paper reviews available literature on the role of fibre in the sugarcane plant. The formation and functions of fibre in the cane-stalk, the variations of fibre in different parts of the stalk, and the influence of climate, fertilization and similar factors on the fibre-content of cane are outlined. The technological properties of fibre in influencing the milling performance of cane and the fuel value of bagasse are also discussed in the paper.

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THE FIRST RECORD OF HEAVY INFESTATION OF *PROCERAS INDICUS* KAPUR IN UTTAR PRADESH

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INTRODUCTION

PROCERAS indicus Kapur is the synonym of *Diatraea venosata*, the systematic position of which has been revised by Kapur (1950). Fletcher (1921) reported its occurrence from all over India with sugarcane and cereals like *juar*, maize and rice as its host plants. Ghosh (1922) recorded it as a regular pest of sugarcane at Cuttack. At Pusa, he observed it very commonly on *Saccharum spontanem* and *juar* and rarely on sugarcane. Gupta (1940) based on his observations in North Bihar reported that during the period it is absent from sugarcane, it is freely available in *S. Fuscum* (Ikri) and *S. spontaneum* (Batri). From these records, it appears that, this species of borer has multiple hosts comprising of sugarcane cereals and wild Sacchari. It is now a regular pest of sugarcane in Andhra, Madras, Hyderabad and Mysore States (Gupta, 1954). In Uttar Pradesh, it occurs with other species of stem borer, but as a very minor pest of sugarcane. In August 1954, a heavy attack of stem borer was reported by the authorities of a Carew & Co., Roza (Shahjahanpur) at their factory farm. The authors, after detailed examination, found it to be *Proceras indicus* Kapur. This was the first occasion, when this borer, hitherto considered as a minor pest of sugarcane, had become a serious pest. Observations on the nature of injury, extent of damage and the varietal behaviour to this pest were recorded and are presented in this paper.

PERIOD OF ACTIVITY AND NATURE OF DAMAGE

The pest was first noticed in the first week of August. Since caterpillars were of fairly advanced stages at this time, the borer appeared to have started its activity in the middle of July. In August, about 50 per cent of the canes were attacked in the autumn-planted crop, whereas the incidence in the spring-planted canes was only 8-10 per cent. It shows that this species of borer has a preference or grown-up canes rather than the shoots. Its attack reached its maximum by the end of September in both the crops, after which the larvae or pupae became untraceable in the grown-up canes. In October, young larvae were found in water-shoots or late tillers, though in very small number. This, however, shows that the borer passes winter in the immature canes. The injury of this borer was confined to the upper half of the cane, bearing soft internodes. The leaves of the attacked canes got pale and the damage could be spotted out from a distance. It could also be detected externally by the presence of frass outside the entry holes and on the leaf sheaths. A single caterpillar bored several internodes of the same cane. It did not bore across the node for reaching the next internode, but usually it came out and entered by cutting through the rind. The eye-buds of the affected internodes in the standing canes sprouted much earlier, thus rendering the cane unsuitable for seed purpose. During the period of its main activity, the maximum temperature ranged between 89·9 to 91·80°F, the minimum between 76·9 to 79·2°F and the mean relative humidity between 85·7 to 87·9 per cent.

These observations are in accord with those recorded by Gupta (1954), who observed 80° to 88°F temperature and 90 per cent relative humidity as optimum conditions for its profuse multiplication in South India. In U.P. such conditions prevailed during July, August and September, while in Madras its maximum activity takes place between September and February.

EXTENT OF DAMAGE AND VARIETAL BEHAVIOUR

At the factory farm, Roza, where these observations were made, a number of cane varieties, both autumn and spring planted, were grown for seed multiplication. A study of the varietal behaviour to this species of borer was, therefore, made. The data on five important varieties, namely Co.S.321, Co.S.443, Co.S.510, Co. 617 and Co.421, recorded at the time of harvest in January 1955, are given in the following table.

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Incidence of and losses due to Proceras indicus *in different cane varieties at Roza*

Criteria for assessment	Time of sowing	Co. S. 321	Co.S. 443	Co.S. 510	Co.S. 617	Co. 421	Average for all varieties
Percentage incidence on stalk basis ...	Spring	18·6	10·0	14·1	14·1	30·4	17·4
	Autumn	64·8	24·6	18·8	10·6	69·2	37·6
Percentage of internodes damaged ...	Spring	9·2	7·0	7·1	10·1	7·4	8·2
	Autumn	9·3	6·1	7·0	7·4	10·2	8·0
Percentage loss in cane yield	Spring	4·7	1·6	1·9	2·9	3·9	3·0
	Autumn	15·8	2·7	2·7	1·2	14·7	7·4
Effect of sucrose per cent juice	Spring	+0·31	—0·62	—0·66	+0·22	+1·43	+0·15
	Autumn	—0·66	—0·90	+0·09	+0·05	—0·63	—0·06

From the above data, it is observed that the average incidence on stalk basis of this borer was 37·6 per cent in autumn and 17·4 per cent in spring-planted crop. This resulted in a loss of 7·4 and 3·2 per cent cane yield respectively. Some of the varieties like Co.S.321 and Co.421 had very high incidence to the tune of 64·8 and 69·2 per cent with a loss in cane yield of 15·8 and 14·7 per cent respectively. These varieties appeared to be more susceptible to this pest as compared to the other three varieties. The incidence on internode basis, which indicates the amount of injury to the bored canes, did not differ much in different varieties nor in the autumn and February-planted crops. No adverse effect on the juice quality of the attacked canes of either crop could be observed.

Summary

A heavy incidence of *Proceras indicus* Kapur, hitherto considered as a minor pest of sugarcane, was observed at factory farm, Roza (Shahjahanpur) during the rainy season of 1954. The optimum conditions for its heavy multiplication, mode of injury, extent of damage and varietal susceptibility to the pest have been recorded. The observations indicate that this species of borer possesses the potentiality to develop into a serious pest under moderately warm and high humid environment. In Uttar Pradesh, its main activity was observed in grown-up cane during monsoon months (July-September). Autumn-planted cane was more heavily attacked than the spring-planted crop. Among the five cane varieties studied for this pest, Co.S. 321 and Co.421 appeared to be more susceptible to the pest. No deterioration in juice quality was observed in any variety, because the period of activity in the mature canes was too short.

Acknowledgments

The authors wish to record their sincere thanks to Dr. R. K. Tandon, Director, Sugarcane Research, Shahjahanpur, under whose direction these studies were made. The help of Sri Ganga Sagar, Field Supervisor, is also acknowledged.

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ARTIFICIAL REPRODUCTION OF BANDED SCLEROTIAL DISEASE OF SUGARCANE

By

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INTRODUCTION

THE disease was reported for the first time in India in 1936 by Subramaniam (1936). It has also been reported from Australia (1936), Java (1936), Formosa (1952, 1948), and Philippines (1931).

This disease caused by *Hypochnus sasakii* Shirai (=*Corticium sasakii*) is of minor importance in Bihar but during the year 1955-56 it became rather serious in some of the varieties grown in the Mycological Experimental Plot (1956) at Pusa. The disease appeared with the onset of rains i.e., from June onwards when the characteristic symptoms of the disease began to appear on the lower leaves and their sheaths (Pl. I, Fig. 1) which were touching the ground. Later on the symptoms slowly became manifest in the upper parts of the plants, and in some of the highly susceptible varieties like B.O. 3, Co. 658 and a few X* varieties mentioned in the text, the leaf crown was also affected killing the shoot outright in some cases and arresting further growth in others. In older diseased leaves black sclerotia were observed. Incidence of the disease taken in third week of July 1955 ranged from 5·6 per cent in Co. 622 to 93·2 per cent in X 4627 on clump basis (Table I).

TABLE I

Incidence of banded sclerotial disease in mycological plot, Pusa during 1955-56

Sl. No.	Variety	Percentage of diseased clumps	Sl. No.	Variety	Percentage of diseased clumps
1.	B.O. 27	0·0	17.	Co. 667	24·3
2.	X 3442	0·0	18.	B.O. 11	25·4
3.	X 3443	0·0	19.	X 2961	32·5
4.	X 3487	0·0	20.	X 3087	32·9
5.	Co. 622	5·6	21.	Co. 313	33·5
6.	Co. 513	5·9	22.	Co. 419	37·8
7.	Co. 602	6·5	23.	B.O. 10	40·6
8.	X 3437	8·3	24.	X 3432	42·1
9.	Co. 617	10·0	25.	X 4009	49·5
10.	X 2752	12·5	26.	X 3451	52·7
11.	Co. 601	14·3	27.	B.O. 17	53·0
12.	Co. 625	14·3	28.	B.O. 21	54·7
13.	X 3477	16·7	29.	X 3505	56·0
14.	B.O. 22	20·0	30.	B.O. 31	56·6
15.	X 2756	20·0	31.	Co. 453	56·9
16.	X 3495	24·0	32.	X 3523	58·1

*X stands for a seedling raised from a cross made at Pusa till it is raised to B. O. status.

TABLE I—*Concld.*

Sl. No.	Variety	Percentage of diseased clumps	Sl. No.	Variety	Percentage of diseased clumps
33.	B.O. 30	58·7	51.	B.O. 25	75·0
34.	X 3861	58·7	52.	X 3896	76·4
35.	X 3858	58·2	53.	X 3532	78·5
36.	B.O. 29	60·6	54.	X 4200	81·7
37.	X 3035	60·6	55.	B.O. 3	82·0
38.	X 3895	62·4	56.	X 4201	82·9
39.	B.O. 15	63·7	57.	X 4493	83·5
40.	X 3967	65·1	58.	X 3410	84·4
41.	X 3448	65·9	59.	X 3522	85·5
42.	B.O. 28	66·7	60.	X 4446	87·2
43.	X 3882	69·3	61.	Co. 658	89·7
44.	X 3439	70·7	62.	X 3770	90·0
45.	X 3852	71·3	63.	X 3527	90·9
46.	X 3860	72·4	64.	X 4494	90·9
47.	X 3570	73·6	65.	X 4552	91·3
48.	X 4291	73·9	66.	X 3795	92·8
49.	X 3839	74·1	67.	X 4627	93·2
50.	B.O. 14	74·8			

ISOLATION AND CULTURAL CHARACTERS OF THE CAUSAL FUNGUS

Hypochnus sasakii Shirai was isolated from the diseased leaves and leaf sheaths on oat-meal agar. The mycelium was septate, branched and sterile measuring on an average 7·9 microns in width. After 3 to 4 days, white bodies developed in culture which on examination under a microscope were found to be immature sclerotia formed by the intertwining of the hyphae (Pl. I, Fig. 2a). In about 5 to 6 days these turned dark brown or black in colour and measured $1{\cdot}4 \pm 0{\cdot}042$ mm. in diameter (Pl. I, Fig. 2b, c). The colour of the mycelium to begin with, was whitish, later turning to greyish.

REPRODUCTION OF THE DISEASE

An experiment was conducted during 1956-57 to reproduce the disease artificially in pots which were filled with:

(a) Soil mixed with debris of the diseased leaves (collected in August 1955) two months before planting.

(b) Soil inoculated with fungal culture on February 13, 1956.

(c) Cultures added to the soil thrice during the year on June 25, July 26 and August 30, 1956.

(d) Ordinary soil (control).

In each treatment there were five pots in which three one-budded setts of B.O. 3 were planted on February 14, 1956. Observations were made every fortnight.

Typical symptoms of the disease appeared on leaves and leaf sheaths in 5 to 6 months after planting in all cases except in controls (Pl. II, Figs. 1 and 2). The results of artificial infection are summarised in Table II. The causal fungus was re-isolated from the diseased leaves and sheaths.

PLATE I

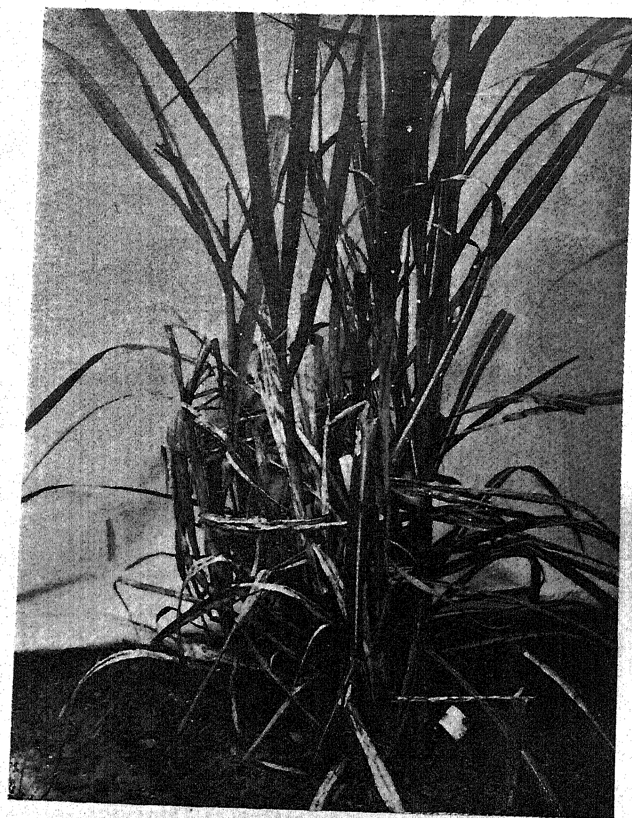

FIG. 1. Affected clumps of B. O. 3 showing symptoms of the disease on leaves and sheaths.

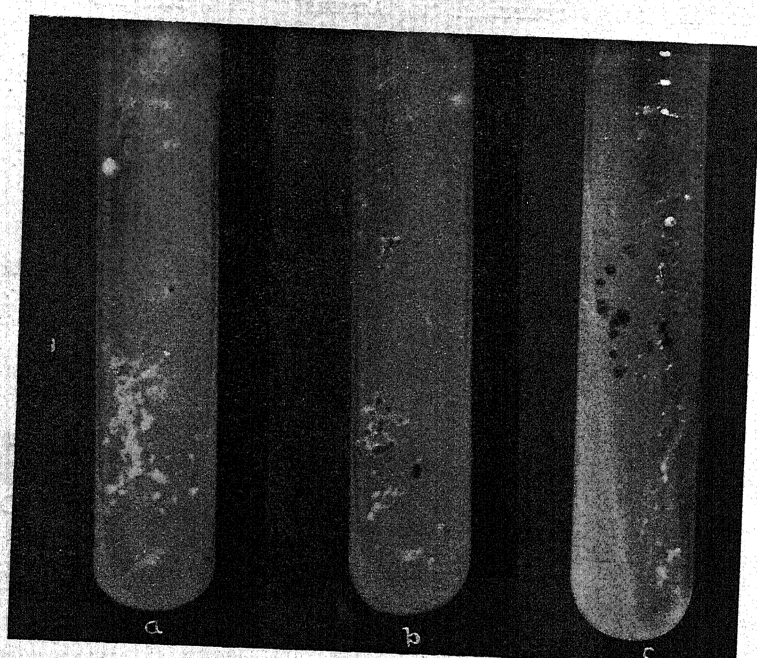

FIG. 2. Stages in the formation of sclerotia in culture on oat meal agar medium. (a) Immature, (b) maturing and (c) matured.

PLATE II

FIG. 1. Artificial reproduction of the disease.
(a) Healthy plant (control).
(b) Affected plant (treated).

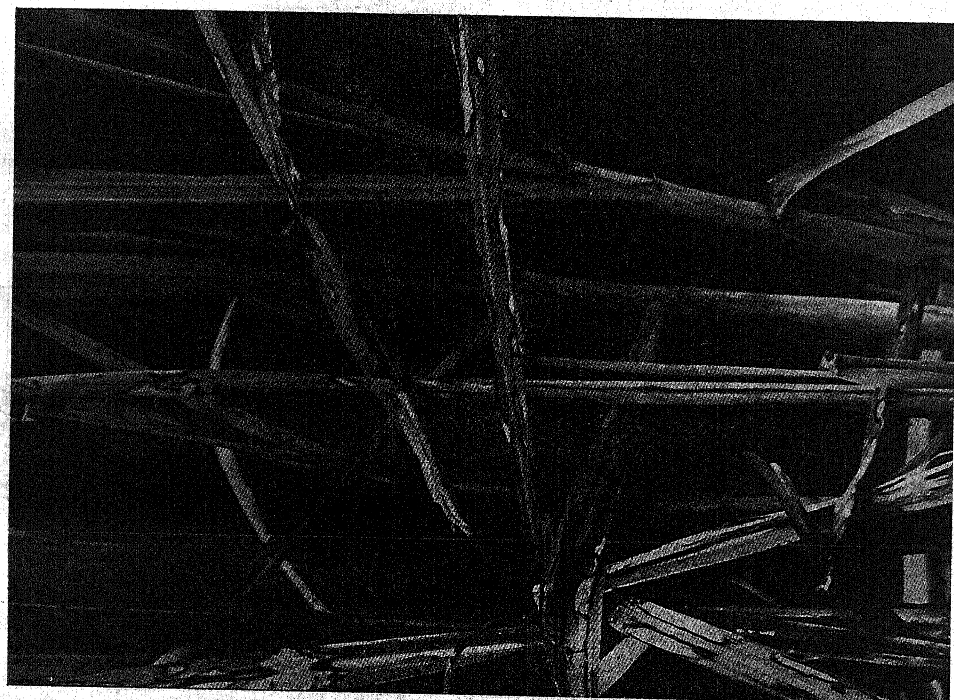

FIG. 2. Enlarged view of Fig. 1 (b).

TABLE II

Reproduction of the disease in pots on the variety B.O. 3 planted on 14-2-1956

Treatment	No. of plants	Date of first appearance of the disease	20th Aug., 1956 No. of plants infected	20th Sept., 1956 No. of plants infected	22nd Oct., 1956 No. of plants infected	Per cent infection
(a) Soil+debris with sclerotia ...	15	4·8—1956	2	2	2	13·2
(b) Soil+culture at planting ...	14	,,	1	1	1	7·1
(c) Soil+culture added monthly	15	,,	9	15	15	100·0
(d) Control (untreated soil) ...	14	...	...	...	...	Nil

The results prove that the fungus is soil-borne. The infection takes place, under favourable conditions of temperature and humidity, if the sugarcane leaves come in contact with the infected soil. The disease is carried over to the next season through sclerotia present in the debris of the affected leaves and sheaths.

SUMMARY

1. Incidence as recorded in 67 varieties in Mycology plot at Pusa.
2. Infection takes place under favourable conditions, if lower leaves come in contact with the infected soil, and spreads upwards.
3. The causal fungus *Hypochnus sasakii* Shirai was isolated from diseased leaves and sheats. Sclerotia in culture measured $1{\cdot}4 \pm 0{\cdot}042$ mm. in diameter.
4. The disease could be artificially reproduced by inoculating soil with fungal culture as also by debris of the affected cane leaves and sheaths.

ACKNOWLEDGMENTS

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FIELD TESTS OF SWINGFOG MACHINE FOR THE CONTROL OF EXTERNAL PESTS OF SUGARCANE

By

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Introduction

With the recent advances made in the formulation of organic insecticides, there has been a simultaneous progress in evolving efficient mechanism for their dispersal. The insecticides can now be applied in the form of thermal aerosol or fog through specially designed machines, the latest of which is the Swingfog Pest Control Unit. It is a portable fog generator, which operates on pulse-jet principle. A series of fuel-air charges fired in the combustion chamber produce pressure waves directed to the exhaust pipe. The insecticide is forced from a pressurised tank and after coming into contact with the hot air it is broken up into very small particles, which form a fog. Thermal aerosols of different insecticides have been tested abroad against several pests. Ditman *et al.* (1946) obtained excellent control of the pea aphid, *Microsiphum pisi* Kalt., with aerosol containing 5 per cent DDT. Glasgow and Collins (1946) reported effective control of house-flies and punkies with 5 per cent DDT fog, using Todd Insecticide Fog Applicator. Wene (1947) successfully controlled garden fleahopper, *Halticus bracteatus* Say. with DDT, Rothane and Pyrethrum aerosols. Gentner *et al.* (1948) employed the aerosol fogging method against codling moth on pear trees, using 4 per cent DDT and achieved very satisfactory results. Elliot and Fitz-john tested Swingfog machine, using 5 per cent DDT and 0·5 per cent BHC oil solutions, against mosquitoes and got 100 per cent mortality in two hours.

The author used Swingfog machine in the control of Pyrilla and Lygaeid bug of sugarcane during the summer of 1955, when these pests appeared in epidemic form. Different doses of endrin, DDT, folidol and basudin were tested in the form of thermal aerosol. The results are presented in this paper.

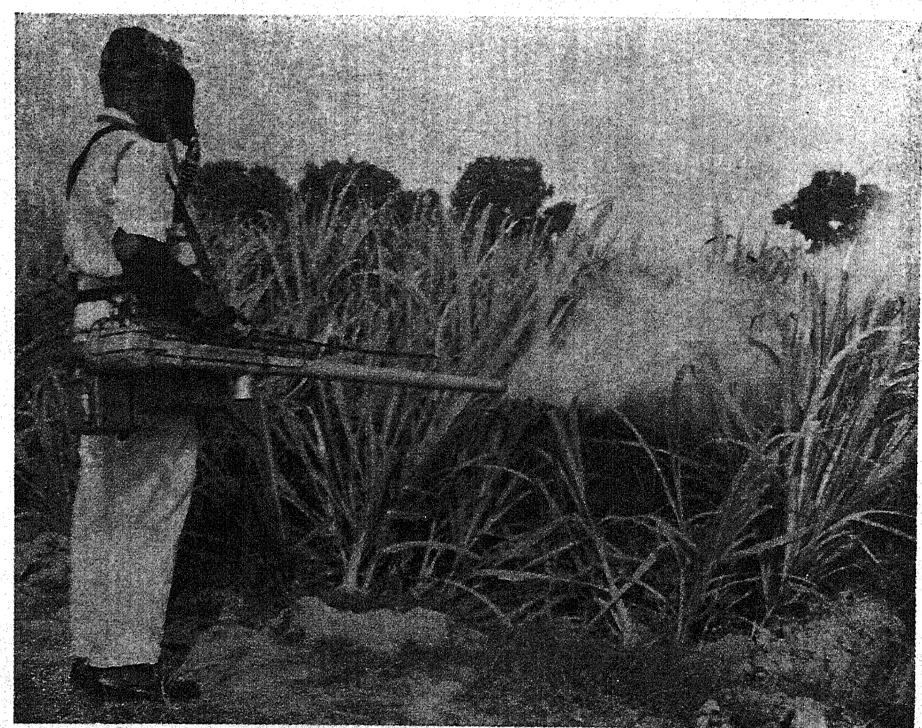

Fig. Swingfog machine in operation.

MATERIAL AND METHOD

The Swingfog machine, Sn4 model, was obtained from Messrs Jardine Henderson, Calcutta. The insecticide regulator valve of the machine could produce fog with droplets of 5-30 microns through fine jet and of 50-60 microns through coarse jet. In these experiments, only the coarse jet was used in order to get heavy fog, which could remain suspended over the sugarcane crop. In all, three experiments were conducted: one on the control of Pyrilla adults, the other on Pyrilla nymphs and the third on Lygaeid bug nymphs.

The experiment on Pyrilla adults was conducted at Sardarnagar factory farm, Gorakhpur, in the first week of May, 1955. A ratoon crop of Co. 453 was selected for the experiment, which was heavily infested with Pyrilla adults ready for oviposition. Four doses of endrin, 0·1, 0·15, 0·2 and 0·3 lb. and two of DDT, 0·5 and 1·0 lb. of the active ingredient per acre were tested. The emulsifiable concentrate of each insecticide was dissolved in kerosene oil and fogged through the machine at the rate of two gallons per acre. Fogging of pure kerosene oil was done in the control plot. The insecticides were applied in the calm hours of morning and evening in order to avoid drift of the fog through wind. The experiment was conducted in non-replicated plots of one-half acre each. The height of the crop was 2½ feet with an average population of 50 to 60 Pyrilla adults per clump.

The experiment on Pyrilla nymphs was carried out at the farm of Carew and Co., Roza, Shahjahanpur, on the 30th May, 1955. The nymphal population of the pest was estimated to be 300 individuals per clump. Two doses of endrin, 0·1 and 0·15 lb. per acre and one of basudin, a phosphorus insecticide containing 20 per cent diazinon, at 8 oz. per acre were applied. Other experimental details were the same as described in the above test.

The experiment on the control of Lygaeid bug was conducted at several private farms in Muzaffarnagar and Meerut districts in the third week of May 1955. The pest was mostly in the nymphal stage with 50 to 60 individuals per affected shoot. Three insecticides, namely, endrin at 0·1, 0·15 and 0·2 lb. per acre, basudin at 4, 6 and 8 oz. and folidol at 1·5 and 3 oz. per acre were tested. The doses of the phosphorus insecticides were in terms of commercial liquid concentrate. The experimental procedure was the same as followed in Pyrilla control.

The efficacy of the insecticides was judged on the percentage reduction in the population of Pyrilla and on the actual count of mortality of Lygaeid bug.

RESULTS AND DISCUSSION

The data on insect mortality obtained through various insecticides are tabulated in Table I.

TABLE I

Effect of insecticidal fog on the mortality of Pyrilla

Treatments	Endrin				DDT		Basudin	Control (pure kerosene oil)
Dose per acre	0·1 lb.	0·15 lb.	0·2 lb.	0·3 lb.	0·5 lb.	1·0 lb.	8 oz.	2 gallons
Reduction in adult population	75%	100%	100%	100%	50%	70%	not tested	No mortality
Reduction in nymphal population 48 hours after application	100%	100%	Not tested	Not tested			25%	No mortality

TABLE II

Effect of insecticidal fog on the mortality of Lygaeid bug nymphs

Treatments	Endrin			Basudin			Folidol		Control (pure kerosene oil)
Dose per acre	0·1 lb.	0·15 lb.	0·2 lb.	4 oz.	6 oz.	8 oz.	1·5 oz.	3·0 oz.	2 gallons
Percentage mortality 72 hours after application	70	80	95	7	8	10	5	66	No mortality

In the control of Pyrilla adults, endrin at a dose of 0·1 lb. per acre gave a mortality of 75 per cent, while 0·15 lb. and upward doses recorded complete mortality of 100 per cent. DDT did not prove very effective in the present test, as a dose of even 1 lb. gave a mortality of 70 per cent, within the same period. For the control of Pyrilla nymphs, two doses of endrin, 0·1 lb. and 0·15 lb. per acre were used and both gave a mortality of 100 per cent. Basudin, which was also tested against the nymphs of Pyrilla, did not prove effective in the aerosol form. A dose of 8 oz. of its liquid concentrate containing 20 per cent diazinon gave a mortality of only 25 per cent. Thus, endrin alone gave satisfactory control of Pyrilla adults as well as nymphs in the aerosol form.

A phytocidal effect, to the extent of 25 per cent of leaves, was noted in DDT-fogged plots. Since no ill effect was observed either in the control plots in which pure kerosene oil at the rate of 2 gallons per acre was used, or in endrin-treated plots, the burning of leaves could be ascribed to the action of the solvent of DDT, which was estimated to be 15 per cent in the fog-solution.

In the control of Lygaeid bug, 0·2 lb. endrin per acre gave a mortality of 95 per cent after 72 hours, whereas its lower doses were found less effective. The minimum effective dose of endrin in the aerosol form against this pest, therefore, seems to be 0·2 lb. per acre, which is double that needed for Pyrilla control. The two phosphorus insecticides, i.e. basudin and folidol, proved ineffective in the aerosol form against Lygaeid bug. The highest dose of basudin at 8 oz. per acre gave a mortality of 10 per cent and 3 oz. of folidol per acre a mortality of 66 per cent. In this experiment, the dead insects were found inside the central whorl of leaves and leaf sheaths, from which it is clear that the insecticidal fog penetrated inside the leaf folds. This was an extra advantage of the fogging method over conventional spraying, in which insecticides remain mostly superficial.

Economics and Efficiency of the Machine

The time recorded for the discharge of insecticidal solution through the Swingfog machine showed that 2 gallons of the liquid could be rejected through the coarse jet in 20 minutes and the fog produced was sufficient to cover an acre of sugarcane crop. The petrol consumption of the machine for treating an acre area was about 2/3 pint, costing four annas. The running charges of the machine and the cost of kerosine oil, to be used as carrier of the insecticide, worked out to Rs. 3·25 per acre. The cost of endrin, which proved effective against both the pests, was Rs. 3·5 to Rs. 5·25 per acre against Pyrilla and Rs. 7/- against the Lygaeid bug. The fogging method of dispersing insecticides eliminated the use of large quantities of water required for the preparation of spray fluid. It is, therefore, more suited for non-irrigated tracts, where supply of water is difficult as well as costly. Moreover, in grown-up crops, plant-to-plant spray or dusting often becomes impracticable. This difficulty is avoided in the fogging method, as the fog spreads to fairly long distances. There are, however, certain drawbacks of the machine. As it produces much heat, the keroseone oil, which is used as carrier of the insecticide, is likely to catch fire if the engine suddenly stops. In such events, the insecticidal valve of the machine should immediately be closed to stop further flow of the oil. Another disadvantage of the fogging system of insecticides is that, on account of the very small particle size, the chemicals have very short persistence on the treated surface and thus the machine can be used only against flying insects, like Pyrilla and Lygaeid bug of sugarcane and not against borers, whitefly, etc. Further, the fog being extremely light, the machine can be operated only during perfectly calm hours, to avoid drift.

Summary

Field tests of Swingfog pest control unit against Pyrilla and Lygaeid bug of sugarcane, using a few insecticides, were carried out at several places in Uttar Pradesh during the summer of 1955 and the results have been presented.

Effective control of Pyrilla nymphs was obtained by using 0·1 lb. of endrin in 2 gallons of kerosene oil and fogged through the coarse nozzle of Swingfog machine in an area of one acre. For the control of Pyrilla adults the dose had to be increased to 0·15 lb. and for the Lygaeid bug nymphs to 0·2 lb. of endrin per acre. For practical purposes, 8 to 12 oz. of 20 per cent Endrin emulsifiable concentrate is to be dissolved in 2 gallons of kerosene oil and fogged in an acre area against Pyrilla and 1 lb. of the concentrate against Lygaeid bug. DDT at the rate of 1 lb. per acre did not give satisfactory control of Pyrilla. A phytocidal effect was also observed in DDT-treated plots, probably on account of the aromatic compounds used as solvent of DDT, the concentration of which was 15 per cent in the solution. The phosphorus insecticides, folidol and basudin, did not prove effective against these insects in the fog condition. The economics and the efficiency of the swingfog machine in the control of sugarcane pests along with the drawbacks of the machine have been given.

ACKNOWLEDGMENTS

The experiments were conducted at Sardarnagar Factory Farm, Gorakhpur, Carew & Co., farm, Roza, Shahjahanpur and a few private farms at Meerut and Muzaffarnagar. The author feels grateful to the managements of these farms for facilities provided by them. Most sincere thanks are due to Dr. R. K. Tandon, Director, Sugarcane Research, Shahjahanpur, for his keen interest in the work.

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Research Notes

Rare Occurrence of the Root Aphid on Sugarcane in South India

Except for the solitary instance of *Tetraneura hirsuta* B. on ragi, the incidence of such forms of root aphids, particularly in pest proportions, is a feature which is something uncommon. A rare species—*Tetraneura cyanodonti* var. *coimbatorensis* George, has however, been recorded and described by George (1925, 1928) on sugarcane roots at Coimbatore. Ayyar (1927, 1940) mentions the aphid as being a minor pest of sugarcane. Fletcher (1929) has collected another species *Geocia spatulata* Theob., on the roots of sugarcane at Pusa. But for these stray observations, root aphids do not appear to have attracted the attention of entomologists anywhere in India. The former species *Tetraneura cyanodonti* var. *coimbatorensis* George—the present name of which is *Tetraneura javansis* v.d. *Goot* according to David (unpublished)—was noted in a fairly serious forms on sugarcane at Perianaickenpalayam (near Coimbatore) during 1957 and it is hoped that the following notes will add something to the existing scanty information on this plant louse.

The insect: The wingless form is whitish in colour, hemispherical in shape, with the leg and antennae short and dark. The body is provided with long, pale white hairs on the sides. The cornicles are small, dark and conical and protrude above the surface of the abdomen.

General habits: Colonies of these aphids are generally located two to three inches below the soil surface. The adults and the nymphs are usually found clustered on the young roots, at their junction with the main stem, but stray specimens of the adults can be noted on the older roots also. The infestation generally starts near the bunds and later spreads to the middle of the field. It is not clear how the infestation starts, but it is suspected to be from the wild grasses growing on the nearby hill ranges.

Nature and extent of damage: These plant lice evidently suck up the cell-sap. When the infestation is severe, the heavy drain of the cell-sap is indicated by the yellowing of the leaves and the consequent unhealthy appearance of the plants. The aphids are usually numerous on the young stages of the crop and though they disappear later, the sickly pallor of the leaves persists even after the plants grow up, irrespective of the presence of the insect. The population of the pest is high during January but tails off by the next month. On a rough estimate, about 5 per cent of the area under observation was found infested.

Control measures: Sugarcane is quite a remunerative crop and the outlay on its preparatory cultivation, manuring, irrigation, etc., is necessarily heavy. The crop is already subject to the damage of a number of insect pests and fungus diseases and the addition of any further enemies should be carefully guarded against. The root aphid should be considered as a pest with serious potentialities. The damage caused may be heavy and the control is likely to be difficult, because of its underground habits, and the impracticability of reaching the insect directly with any insecticidal wash or dust. It was too late during the current season to try any control measures. But the application of B.H.C. 50 per cent water suspension at 0·1 per cent being effective against the ragi root-aphid, the same may be tried against this pest also.

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Failure of Leaves to Unfold

Failure of leaves to open out was reported as " tangled " or " twisted " top from Hawaii (Lee, 1928), Cuba (Pirode, 1931a), Philippines Islands (Rolden, 1931b) and by Indian workers (Arakeri *et al.*, 1955; Rafay, 1956a; Chona, 1956b), from Bombay State where it has been taken to be a new disease. Arakeri (1955) observed that the " disease was found only in those fields where cane was grown from the seed that had not been changed for a period of 5-6 years ". So far its casual agent, or factors predisposing the crop to this entanglement of leaves have not been determined. Rolden (1931b) was of opinion that it was purely

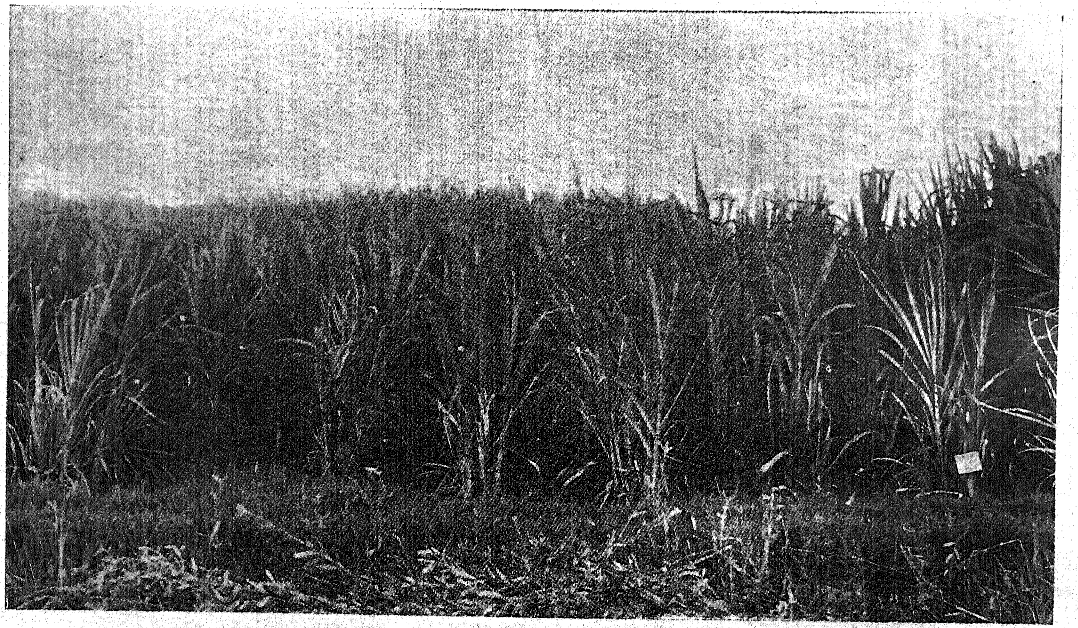
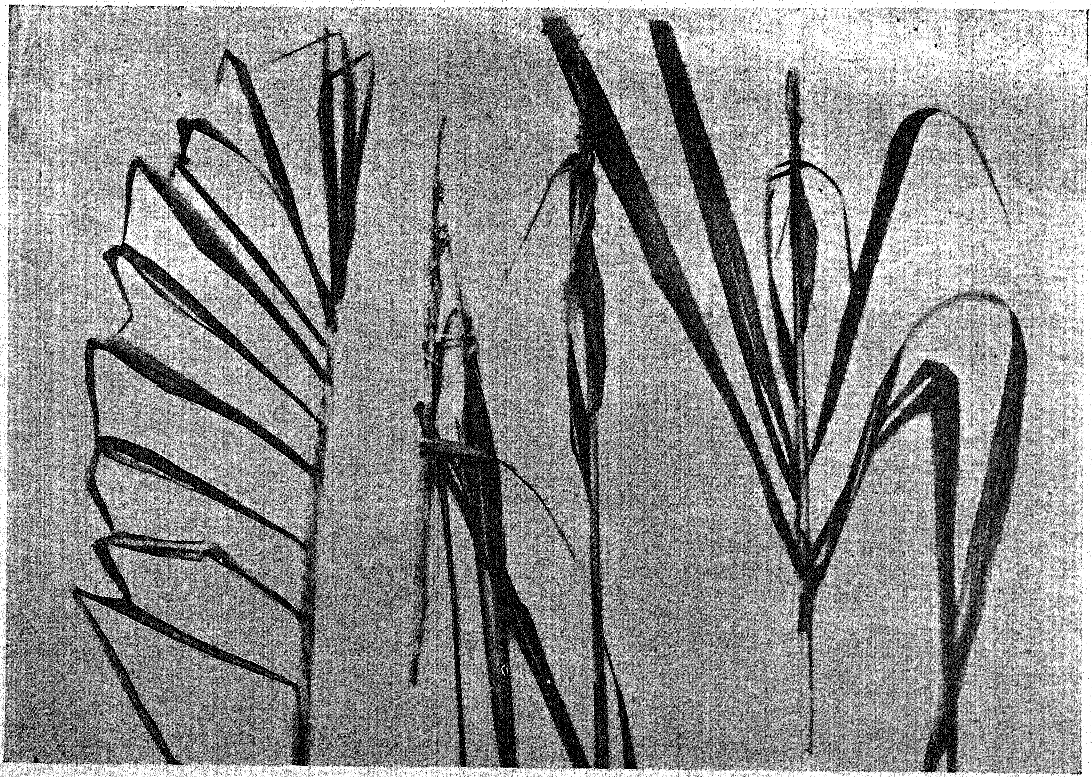


FIG. 1



A B C D

FIG. 2.

of mechanical nature: like the falling of a card in the proverbial house of cards resulting in the collapse of the whole structure,—if one leaf failed to open out properly, it impeded the unfurling process of all the others. This view however does not seem to be tenable, because at Pusa in 1948-49, the whole of the plot of H.M. 89 was found affected by this malady (Fig. 1) showing different patterns and degrees of entaglement (Fig. 2a, b, c, d). There must have been some factor which appeared to affect all the stalks, but in varying degrees. Mechanical failure pre-supposes an element of chance.

Crop raised from affected seed did not show this disturbance in the next season or thereafter; nor has it been noted since then at this place, although similar cases of more or less intensity in different years have been observed in Champaran district.—K. L. Khanna and S. L. Sharma, Central Sugarcane Research Station, Pusa, Bihar.

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A Rust on Sugarcane in Bihar

A RUST was reported to occur on sugarcane from peninsular India (Patel *et*, *al.*, 1950; Chona and Munjal, 1950; and Chenulu, 1954) where the disease has acquired some economic importance especially in Bombay State. Co. 475, a promising variety which had potentialities to replace Co. 419, had to be withdrawn from that State because of its susceptibility to this pathogen. In Northern India it was recorded in April 1956 only at Gola Gokaran Nath (District Kheri) in Uttar Pradesh on CoS. 510 (*Indian J. Sug.cane Res. & Dev.*, 1957, **1** (2): 104).

In Bihar also a sugarcane rust has been noted for the first time in recent years. The disease was found at Motihari in Champaran district towards the end of May 1957 on CoS. 416 and CoS. 510 while B.O. 10, B.O. 32, Co. 678, Co. 684, Co. 685, Co. 740, Co. 1103, Co. 1119, Co. 1120 and CoS. 443 growing in the same field were free of the disease.

The rust was much more severe on CoS. 510 than on CoS. 416. Old leaves of almost all the clumps of the former variety were affected showing a pustule density of 40 to 65 per cent on the Cobb's scale for cereal rusts (Chester, 1948), and nearly 100 per cent in some of the oldest leaves. Leaves originating in the middle portion of the plants were comparatively less rusted while the topmost 3 to 5 leaves were quite free. In CoS. 416 which was growing adjacent to CoS. 510 with a path of 4′ in between, the pustule density was 10-25 per cent in 10-15 per cent clumps.

TABLE I

Average size of 300 uredo-spores of the rust on sugarcane (CoS. 510) and those of Puccinia Kuehnii *found on* E. arundinaceus

Particulars	Sugarcane (CoS. 510)	*E. arundinaceus*
A. Length: Range	42 μ-16·5 μ	42 μ-21 μ
(b) Average	29·7μ*	28·8 μ*
(c) Standard error ...	0·33 μ	0·25 μ
B. Breadth: (a) Range ...	28·5 μ- 13·5μ	30 μ-12 μ
(b) Average... ...	21·9 μ†	20·7 μ †
(c) Standard error ...	0·22 μ	0·42 μ

*Difference significant at 5 per cent level. †Difference significant at 1 per cent level.

The average length and breadth of the uredospores of sugarcane rust and of that found on *Erianthus arundinaceus* along with the standard error and range are given in Table I. On applying 't' test it was found that the difference in the lengths and breadths of the uredospores of the two rusts were found to be significant respectively at 5 per cent and 1 per cent level. Moreover, teleospores were found to have developed in large numbers in rust samples collected on CoS. 510 from Motihari on 22-8-1957, while they were never formed in the rust on *E. arundinaceus* during the last 10 years. To determine the pathogenicity of the two rusts and therefore their identity to a great extent, cross inoculations on CoS. 416, CoS. 510 and *Erianthus arundinaceus* are being made. Later on, susceptibility of some of the commercial canes like B.O. 3, B.O. 10, B.O. 11, B.O. 14, B.O. 17, Co. 453 and Co. 513 will be tested.—S. L. SHARMA, R. K. SINGH, and B. SARKAR, Sugarcane Research Institute, Pusa, Bihar).

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LONGEVITY OF RED ROT FUNGUS (*GLOMERELLA TUCUMANENSIS* ARX AND MULLER) IN SUGARCANE DEBRIS IN SOIL

IN compliance with the recommendations of the *Ad hoc* Mycological sub-committee of the Indian Central Sugarcane Committee, which met at New Delhi on February 4, 1956, an experiment was laid out to see how long the casual agent of red rot was able to survive in plant debris in soil. Heavily-infested stalks of Co. 453 were chopped into small bits and on March 9, 1956 applied to rows 3 in. apart in two adjacent plots, each 60′ × 33′ in which Co. 453 was planted in first 2 rows. Subsequent plantings done with the same variety in alternate plots, the date of first appearance of the disease and the percentage of lumps affected till A ugust 13, 1957 are given in Table I. Observations in these plots are still being continued.

TABLE I

Longevity of red rot fungus in soil

Date of application of debris—9-3-1956

Date of planting	Percentage of infection till 13-8-1957	Date of the first appearance of disease	Incubation period in days	Remarks
9-3-1956	100·0	1-6-1956	82	
9-5-1956	100·0	3-7-1956	55	
21-6-1956	82·2	30-11-1956	159	
3-8-1956	100·0	12-11-1956	99	
28-8-1956	45·4	18-2-1957	170	
28-9-1956	57·5	30-11-1956	62	
12-10-1956	9·7	4-1-1957	82	
22-11-1956	3·8	2-7-1957	220	
22-12-1956	20·8	18-4-1957	116	
22- 1-1957	6·6	3-6-1957	131	
21- 2-1957	...	...	...	Red rot has not appeared as yet.
21- 3-1957	...	...	...	
21- 4-1957	2·7	2-8-1957	101	

From the observations made so far it would appear that red rot fungus in cane debris was viable till April 21, 1957 i.e., nearly 13½ months after its application to soil. The period for which soil containing infected debris can serve as a source of infection has already exceeded by six months the limit of seven months reported earlier for soil artificially infected with red rot culture (Khanna, K. L., *Ann. Rep. Sug.cane Res. Sta., Pusa, Bihar for the year ending* 31*st May*, 1943). The experiment is being repeated this year also.

The presence of red rot fungus in soil nearly 13 months after harvest thus precludes all chances of raising healthy crop in the next season in an infected field at Pusa and in the greater part of the sugarcane tract of the State where climatic conditions are in no way severer than those at Pusa.—S. L. SHARMA and H. C. JHA, Central Sugarcane Research Institute, Pusa, Bihar).

MORE AND BETTER CANE PER ACRE

By

P. P. CHANDRA and A. S. SHARMA

(Indian Central Sugarcane Committee)

THE sugar industry is the second biggest industry of our country and, after Cuba, India is ranked as the largest sugarcane producing country of the world. The Indian sugar industry, however, lags far behind the other cane-producing countries in respect of both acre yield and sugar recovery. The main problem is to obtain more and better cane per acre. The position of sugarcane as a cash crop and also as a satisfactory rotational crop is of vital importance in the agriculture economy of the country and requires concerted attention on the part of all concerned.

Low yields per acre of sugarcane and poor recoveries may be mainly attributed to the fact that the results of research conducted at the various research stations and subsidiary centres in the various regions have not been carried to the doors of cane growers on any extensive scale. Dr. C. van Dillewijn, F.A.O. sugarcane expert, during his tour in India, also remarked that there was a great gap between India's potential capacity and the actual results obtained so far.

There is no doubt that the sugarcane growers have duly recognized the high potentialities of the improved varieties of sugarcane combining high yield and sucrose content as well as their power of resistance to adverse environmental conditions, and this is why the low-yielding indigenous varieties have readily been replaced.

The improved varieties now occupy over 95 per cent of the total area under sugarcane. The cane growers, however, have not been able to provide the essential wherewithals in the form of adequate quantities of manures and fertilizers and higher doses of irrigation. Sugarcane, being a heavy feeding corp, requires judicious manuring at various stages of its growth and develpoment and if the requisite amount of nutrients are not supplied, the yields per acre are affected adversely.

With the spread of improved varieties, the All-India average yield of cane increased from 10 tons to 14-15 tons per acre. This figure, however, has remained stationary during the last decade and has even suffered a drop at times. This, does not reflect any discredit on the improved varieties which possess potentialities for giving high yields under optimum conditions. The maximum yield in prize plots during recent years in North India has been of the order of about 76 tons, while in Bombay record yields of 127·4 tons have been obtained with 14·1 tons of sugar per acre. Of late, in Madras the highest acre yield obtained has been of the order of 129·03 tons per acre which compares very favourably with the world record. This clearly indicates that the improved varieties can produce yields equalling those of the best varieties commercially grown in countries like Java, Hawaii, British West Indies etc., provided they are given the ideal conditions of growth and nourishment.

SUGARCANE DEVELOPMENT

In order to carry the results of sugarcane research to the doors of the cane growers, to bridge the gulf between the research stations and the cultivating community and to increase the production of sugarcane by intensive methods of cultivation especially in the factory zones, the Indian Central Sugarcane Committee in 1948-49 initiated a 5-year sugarcane Development Scheme in the States of U.P., Bihar, Punjab, Bombay, Madras, West Bengal and Orissa. Special attention was paid in the development schemes to the provision of (i) adequate irrigation facilities; (ii) seed nurseries for the supply of adequate quantities of disease free and healthy seed; (iii) adequate manures and fertilizers of the right type; (iv) employment of trained and technical personnel to carry the results of research to the cane growers; (v) efficient watch and ward service for the protection of the crop against pests and diseases; (vi) demonstration farms; and (vii) soil extension service. This scheme terminated on the 31st March, 1953, but was subsequently extended with certain modifications for a further period of 3 years up to 31st March, 1956 so as to co-terminate with the First Five Year Plan of the Government of India. The Indian Central Sugarcane Committee has contributed Rs. 62·4 lakhs towards these schemes, besides an equal or even larger share paid by the various State Governments concerned. As a result of the above development schemes, considerable progress has been made both in regard to yield and quality of cane now grown in the development zones as will be seen from the statement on page 69.

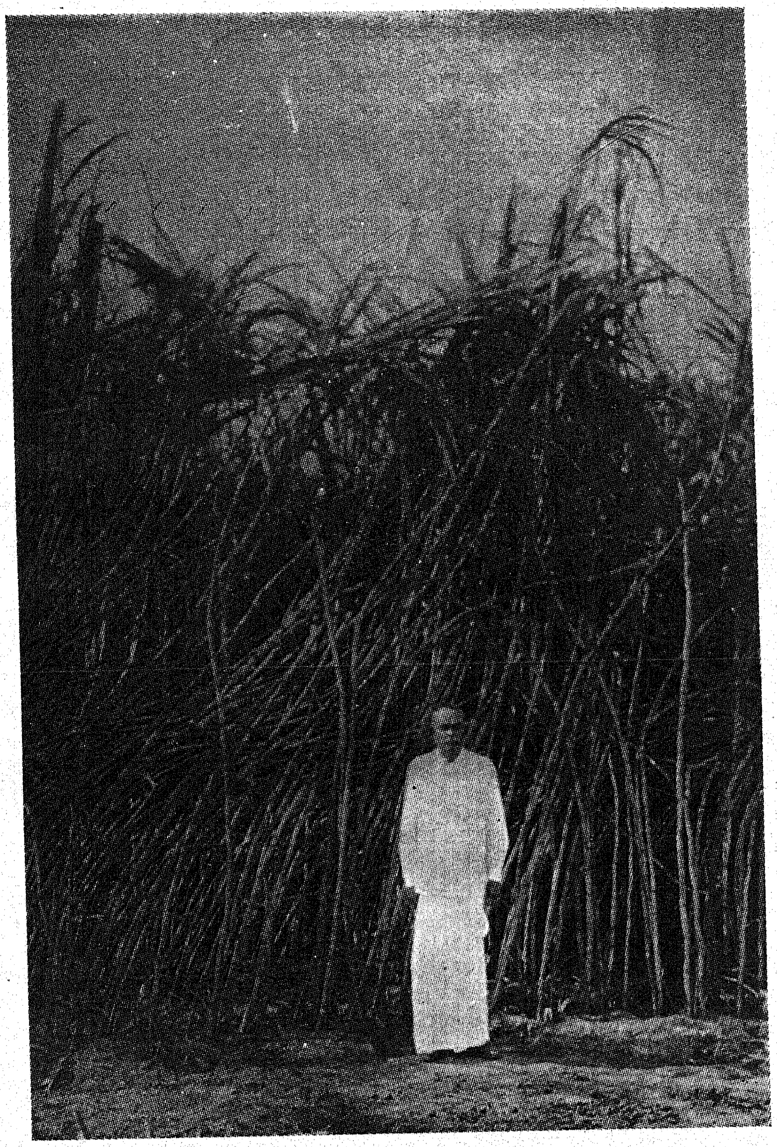

FIG. 1. Cane Competition plot of Shri T. Konda Reddiar, Radhapuram, Madras in which a record yield of 129·03 tons per acre has been obtained.

Figures for different areas could not be estimated. During 1955-56, however, the average yields for *Adsali*, plant and ratoon crops in factory areas have been 62·26 , 48·85 and 40·09 tons per acre respectively as against 61·82, 46·29 and 36·14 tons during 1954-55.

Scientific Crop-cutting Experiments

It will be observed from the fore-going statement that the Sugarcane Development Schemes have covered an area of more than 8 lakh acres by the end of 1955-56 mainly in the factory zones of the country. Determined by proper scientific crop-cutting experiments, the acre-yield of sugarcane in blocks brought under the intensive development has been noticed to be 23·8 tons per acre as compared to an average of 13·9 tons per acre in the entire sugarcane area of 39·32 lakh acres under cane during the year 1954-55.

Statement showing the average acre-yield targetted and achieved in the Development areas as a result of the working of the Sugarcane Development Scheme

S. No.	State	Average yield per acre before initiation of scheme (tons)	Average acre yield targetted at the end of 1955-56 (tons)	Average yield per acre achieved in development areas during the year 1955-56 (tons)	Average under development zones during 1955-56
*1.	U.P.	12·87	20·5	*15·4	4,10,000
2.	Bihar	12·0	20·0	18·80	1,54,680
3.	Bombay	31·0	‡1. 42·1 2. 24·0 3. 28·0	N.A.*	86,000
4.	Madras	25·7	36·5	37·43	42,403
5.	Andhra	25·0	34·0	35·00	67,868
6.	Punjab	12·9	26·0	†18·4	33,000
7.	West Bengal	16·1	22·0	22·0	9,373
8.	Mysore	18·8	35·0	32·093	8,583
					8,01,907

*Lower yields in 1955-56 due to high floods in East U.P. and severe drought followed by unusual floods in West U.P.
†Lower yields due to long drought and delayed monsoons.
‡1 Deccan Canal Area.
2 Karnatak Area.
3 Kolhapur Area.

Achievements under the First Plan

The development work for the improvement of cane carried out under the aegis of the Indian Central Sugarcane Committee has given encouraging results. The work done has however, not reflected itself significantly in the All-India figures so far because the area covered by the development schemes forms only about one-fifth of the total sugarcane acreage in the country. The remaining four-fifth of the area has not been properly attended to and has even been somewhat neglected. Natural calamities like floods, drought and spread of diseases and pests have also adversely affected the development of the sugarcane industry. In spite of these difficulties, the total sugarcane production in the country during 1955-56 has been of the order of 580 lakhs tons as against the targetted figure of 631·6 lakh tons.

Targets for the Second Plan

Under the Second Five Year Plan, it is proposed to bring almost the entire existing sugarcane area—factory as well as non-factory area—under development without bringing more area under sugarcane. The present acreage under cane will be intensively developed and more area diverted to other crops without adversely affecting the production of sugarcane and sugar. The second Five Year Plan has fixed a target of 780 lakh tons of sugarcane production, taking into consideration the achievements made under the first plan. A total sum of Rs. 935 lakhs has been provided under the Second Five Year Plan in order to achieve the above targets as specified by the Planning Commission. Out of this amount, the share of the State Governments will be to the tune of Rs. 695 lakhs and the Indian Central Sugarcane Committee would provide a sum of Rs. 300 lakhs by way of subsidy and Rs. 50 lakhs by the way of loans to the various State Governments.

Intensive Manuring Campaign and Publicity

Encouraged by the success achieved in the Japanese method of paddy cultivation, it was decided to start a similar campaign for sugarcane crop during 1954-55. Since manuring forms the most important item of cane cultivation and is also directly responsible for increasing sugar per acre, it was decided to give a concrete shape to this aspect of cane cultivation. A beginning was made in June 1954 in the three main sugarcane

producing States of U.P., Bihar and Punjab for top dressing of the standing sugarcane drop with ammonium sulphate. An area of 1·7 lakh acres was covered during 1954-55 as against the target of 2·24 lakh acres. The average yields as worked out from the data of half-field demonstrations available from these states showed an increase of 25 to 30 per cent in yield in the areas covered under the campaign.

FIG. 2. Sugarcane crop of Co. 453 in village Datauli (Mankapur Zone) U.P., treated with Ammonium sulphate.

Subsequently a target to cover an area of 9·3 lakh acres in 1955-56 was fixed for the States of U.P., Bihar, Punjab, M.P., Bombay, Madras, Mysore and Andhra. The area actually covered under the scheme came out to 8·06 lakhs acres. The quantity of fertilizers distributed was 10 lakh mds. The acre yield obtained as a result of the use of optimum doses of manures indicated the possibility of an increase in the acre. yield of sugarcane by 17 to 25 per cent. This indication was clearly perceptible in spite of severe damage caused to the sugarcane crop during September and October 1955 by unprecedented rains and floods accompanied by strong winds.

The intensive manuring campaign and publicity has now been accepted as an essential item of development for obtaining more and better cane per acre during the Second Plan. A target of 15 lakh acres to be covered under this campaign was fixed for the year 1956-57 out of which the total area covered was of the order of 14·10 lakh acres and a quantity of 30·44 lakh mds. of fertilizers was distributed in the various States.

The Central Agricultural Officers appointed under the scheme have conducted intensive tours in the areas and did a fair amount of publicity and propaganda for obtaining more and better sugarcane per acre. The Indian Central Sugarcane Committee has brought out a number of posters, brochures and Flip Books which are quite striking and conform to a high standard of modern forms of publicity.

CONCLUSION

Efforts have now to be directed towards increasing the production of sugarcane by intensive methods of cultivation in factory zones and providing better transport facilities. Intensive development of cane cannot progress unless adequate facilities are available to the growers for transporting their produce from the fields

to the factories. The Committee has therefore, sanctioned a subsidy of $33\frac{1}{3}$ per cent for the construction of *pucca* roads in factory areas. If proper facilities in the shape of adequate irrigation-water and sufficient manures and fertilizers are made available to the sugarcane growers it should not be very difficult to achieve the Second Plan target for sugarcane production. There is no doubt that the work will entail heavy and concerted efforts on the part of field workers and careful scrutiny, watch and guidance by the officers in charge of development schemes. Fortunately the workers, both on the research and development side, as well as those under the community projects administration, are alive to the need for proper attention towards the task of producing more and better cane in the areas of their jurisdiction.

Our country has not only become self-sufficient in sugar but has now started exporting sugar in large quantities and at cheap rates. A target of two lakhs tons for the export of sugar has been fixed for the current year and 1,42,000 tons of sugar have already been exported from this country, which has earned valuable exchange.

Success in sugarcane cultivation calls for harmonious combination of the different growth factors of production and attention to any single factor is not at all adequate. Careful and proper planning and concerted efforts of all concerned to provide the wherewithal necessary, coupled with the harnessing of the forces of nature and exploiting the resources of science are bound to lead to a more prosperous sugarcane industry, resulting in more production of cane and sugar in the country.

Miscellany

AERIAL SPRAYING OF INSECTICIDE AGAINST CANE BORERS

EVERY year during the dry summer months a large quantity of cane is damaged by stem borer as well as top shoot borer, resulting in a considerable loss in sugar production. Normally these pests are fought by handspraying of chemicals. In the mill areas sugarcane is grown in concentrated zones. Naturally the borers spread quickly. Effective power spraying is not easy in sugarcane as in other crops. Naturally, some other means had to be found. It was in this way that aerial spraying came into vogue in other countries, particularly Australia, and now in India also.

Aerial spraying of sugarcane was first done for controlling pyrilla in Bhopal. But, for stem borer aerial spraying is being done in West Bengal for the first time in India. The only sugar mill in West Bengal at Plassey faced difficulties in the last season due to a very high incidence (5 to 40 per cent) of borer which threatened normal sugar production.

Under the auspices of F.A.O. the Government of India (Plant Protection Adviser) obtained some planes for pest control from Canada. One such Beaver plane was borrowed at the rate of Rs. 4-4-0 per acre of spraying—the target being 6,000 acres for the present,—with the additional help of ground spraying units of about 300 hand sprayers and a dozen power sprayers.

FIG. 1. Beaver plane spraying insecticide on sugarcane field.

Work was started on the 1st May 1957, and so far about 2,000 acres have been covered. The maximum coverage by aerial spraying is 100 acres per day, wheras by hand sprayers it is $\frac{3}{8}$ acre per day. The tank capacity of the plane is 150 gallons and at the rate of 3 gallons per acre, 50 acres are covered in each trip. Normally, spraying is done early in the morning when wind velocity is lowest so that there is as little drift as possible and consequent loss due to wastage is also minimum. When weather favours, an

evening trip is also undertaken. From both ends, men with flags mark the area to be sprayed; the plane flies low, almost touching the canes and the boom spray opens giving a trail of mist falling uniformly on the canes. As soon as the plane reaches the other end with flags the nozzles are stopped, the plane turns round and repeats the performance from the other end. This continues for 30 to 40 minutes. At the end of each spraying the flagmen demarcate the area next to be sprayed, to the pilot.

A mixture of BHC and DDT wettable powders at the rate of 5 lbs. per acre was used in water for the spray and endrin, (endo-isomer of dieldrin) a Burmah shell product, in the from of emulsifiable concentrate was also used at the same dosage of 5 lbs. per acre in water.

This quick and easy handling of pest control will bring a new area of plant protection in India in years to come.—Murari Prasad Guha, Assistant Publicity Officer, Directorate of Agriculture, West Bengal.

AN EPIDEMIC OF CANE BORER, *CHILO TUMIDICOSTALIS* HMPSN.

THE cane borer *Chilo tumidicostalis* Hmpsn. occurred in an epidemic form in July and August 1956 at the farms of the Ramnugger Cane & Sugar Co., Ltd., Plassey (District Nadia, West Bengal). The opportunity was utilized for collecting observations on the habits, life history and control methods for this species of borers.

The presence of the borer was indicated by the dry crown of leaves in some of the canes of the infested clumps. The borer injury was of two distinct kinds—(a) Primary infection and (b) Secondary infection.

Primary infection was caused by the newly hatched larvae congregating in the top three to five internodes of a cane. Top leaves of such canes were either completely dry or were drying. The nodes of the damaged internodes had thrown out elongated sett roots which enveloped the stem in a network of rootlets and root-hairs. Side-shoots were also seen sprouting out in some cases.

Secondary infection was caused by grown-up borer larvae migrating to neighbouring canes or to the lower healthy portion of the canes showing primary infection. In this case, cane tops did not dry up, though individual caterpillars were observed to bore one to five internodes in a cane.

The borer was observed to infest severely the autumn (1955) planted cane varieties—Co. 419, Co. 453, Co. 527 and B.O. 11. The infestation was markedly low in varieties planted late in the season.

At Plassey, mating and egg-laying were observed to take place only at night. The eggs were laid in typical pyramid fashion on the underside of the first, second and third recently-opened leaves as well as in leaf-sheaths and on canes, in tiers of two to four eggs. The caterpillars from one egg-mass hatched almost simultaneously and bored into one single top internode of the cane. After about ten days, the borer larvae dispersed to adjoining canes, each boring into a separate internode. The incubation, larval period and the pupal stage lasted for 7, 26 to 46 and 6 to 11 days, respectively during July and August 1956. The moths emerged at night and were easily attracted to light. In the following life-cycle it was difficult to ascertain the beginning of the brood, because moths, eggs, larvae of different sizes, as well as pupae were available simultaneously in abundance. The egg-masses of a third life-cycle were deposited in the beginning of October 1956 and the hatching larvae were observed to go into hibernation.

The following control measures were taken up for bringing down the borer infestation and checking its spread: (1) Collection of moths by means of light traps. (2) Hand-picking of the egg-masses. (3) Removal of cane tops showing primary infection. (4) Spraying with Endrin and DDT at the rate of 1 lb. per acre.

Further studies are in progress.—B. D. Gupta and P. N. Avasthy, Indian Institute of Sugarcane Research, Lucknow.

CHILEAN NITRATE AS NITROGENOUS MANURE

TO test the efficacy of chilean nitrate as a nitrogenous manure, as compared to the normal use of ammonium sulphate in combination with oil cakes, a bulk trial was conducted at the Sugarcane Research Station at Gudiyattam from 1948-49 to 1950-51. The nitrogen dosage applied was 200 lbs. per acre in both the treatments.

The results of this trial indicated an increased yield of 5·87 tons per acre when manured with chilean nitrate as compared to the usual mixture of oil cake and ammonium sulphate.

Though the cost of the manure by using chilean nitrate was more by about Rs. 50 per acre, it was compensated by an additional income of Rs. 190 per acre.

The results require further confirmation by laying out of replicated trials.—*Directorate of Agriculture, Madras.*

DUAL ACTION SEED TREATMENTS FOR SUGARCANE

By

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(Begg, Sutherland & Co., Private Ltd., Marhowrah, Bihar)

INTRODUCTION

GERMINATION in sugarcane is one of the most important phases determining the performance and ultimate yield. It would be realised that the quicker the germination the better are the chances of a good stand, thereby resulting in higher yield. In sub-tropical areas where cold weather prevails from November to March, the growing season is hardly eight months and sugarcane has to make all its growth during the monsoon months of June to September. The sugarcane cuttings planted in February take 5 to 6 weeks, and in the case of autumn plantings two months may elapse, for full germination. It was observed that varieties like B.O.17 and CoS.443, recently released for general cultivation, on the average, take more time for germination than other varieties planted under similar conditions. If planting is done under dry conditions at a depth of 6 to 8″, particularly in soils with low moisture index, as practised in North Bihar and Eastern U.P., germination is delayed. Under such conditions, the sugarcane termites cause serious damage to the setts, especially in light soils, affecting the germination. The menace manifests itself right from the time of planting the setts and continues till the harvest of the crop. Also sett rotting due to soil fungi is favoured by the very conditions that retard germination and growth of the plant.

With a view to overcome some of the factors responsible for poor germination and to establish good stand of the crop, several attempts have been made in the past by treating cane setts with various solutions—cold water, hot water, lime water, bordeax mixture etc. (van Dillewijn, 1952).

Although some increase in germination and yield of cane often result from such treatments, these have not been adopted by growers because the benefits derived generally have not been sufficient to justify the expense. A deterrent factor is also the fact that the treatments involve great practical difficulties as it is necessary to soak the seed material for a period of several hours. It is claimed that various organo-mercury fungicides like Aretan, P.M.A. and Agallol are useful in accelerating the germination of cane setts. Encouraging results in germination by dipping the cane setts before planting in these organo-mercury compounds have been reported by McMartin (1954) in South Africa, Evans and Wiehe (1947) in Mauritius and Chin (1949) in Formosa (quoted by van Dillewijn, 1952). Trials carried out at Hawe Hill, Brisbane and at Mt. Edge Combe, Natal, indicated the usefulness of Aretan and P.M.A. in hastening germination apart from the sterilisation effects on cane setts. In India, Khanna *et al* (1957) have suggested chemotherapy of sugarcane setts by the use of ' Aretan ' as preplanting treatment in view of its remarkably beneficial effect on the stand and tonnage of crop. Experiments conducted in the group factories under the management of Messrs. Begg, Sutherland & Co., Private Ltd., (1953-55) showed the beneficial effect of soaking setts for 10 minutes in Aretan or Agallol solution in hastening germination, particularly in slow germinating varieties, like B.O.17 and CoS. 443. It was observed that this treatment failed to show favourable increasse in yield in places where the incidence of termites was higher, in spite of the initial higher germination.

The possibility of combining pest control and stimulating germination in one treatment has been indicated by van Dillewijn (*loc. cit*). The development of dual action seed dressings to protect the crop against losses caused by both seed and soil-borne diseases and soil insect pests is only of recent origin. Chemically, the dual action seed dressings contain an organo-mercurial fungicide for the protection of the crop against fungal diseases and an insecticide for the protection against soil insects. Hampton (1955) reports the benefical aspects of such treatments on germination and yield of cereals by offsetting the damage caused by soil insects. Of late, the dual action seed dressings are becoming more popular in the West and it is felt that these newer, recently introduced dual action seed-dressings would play an important role in successful cane cropping especially under the dry conditions of North Bihar and Eastern U.P.

Attempts were made, therefore, by M/s. Begg, Sutherland & Co., Private Ltd., (1954-55) to hasten the germination and to control termites by the use of Aretan-Gamma BHC, a fungicide/insecticide compound supplied by M/S. Imperial Chemical Industries (India) Ltd. Encouraged by the partial success with Aretan-Gamma BHC and after several preliminary trials carried out with various organo-mercury/insecticide compounds, a detailed investigation on field scale was carried out at Marhowrah during the 1955-56 season. In this paper are

presented the results of the effects of seed treatments with fungicide/insecticide mixtures on germination, tillering, growth, incidence of termites and yield of cane.

Methods and Materials

The experiment wes laid out in sandy loam soil moderately infested with termites, in randomised blocks with 5 replications and 8 treatments including one control (no treatment), individual plot size being 1/40th acre (11 yds. x 11 yds). The variety planted was B.O.17, a slow germinator. The setts, prior to planting, were given 10 minutes' steep in the following solutions and planted after draining off the solution completely. The treatments were as under:–

T1. Aretan 1 lb in 20 gallons of water.

T2. Aretan-Gamma BHC 1 lb in 20 gallons of water.

T3. Aretan 1 lb+Aldrin 1 lb 40 per cent E.C. in 20 gallons of water.

T4. Aretan 1 lb+Dieldrin W.P. 50 per cent ½ lb in 20 gallons of water.

T5. BHC 50 per cent W.D.P. 1 lb in 20 gallons of water.

T6. Aldrin 40 per cent E.C. 1 lb in 20 gallons of water.

T7. Dieldrin ½ lb. 50 per cent W.P. in 20 gallons of water.

T8. Control (no treatment).

Thirty-two three-budded and one 4-budded setts (100 buds) were planted in each row as this facilitated easy recording of germination.

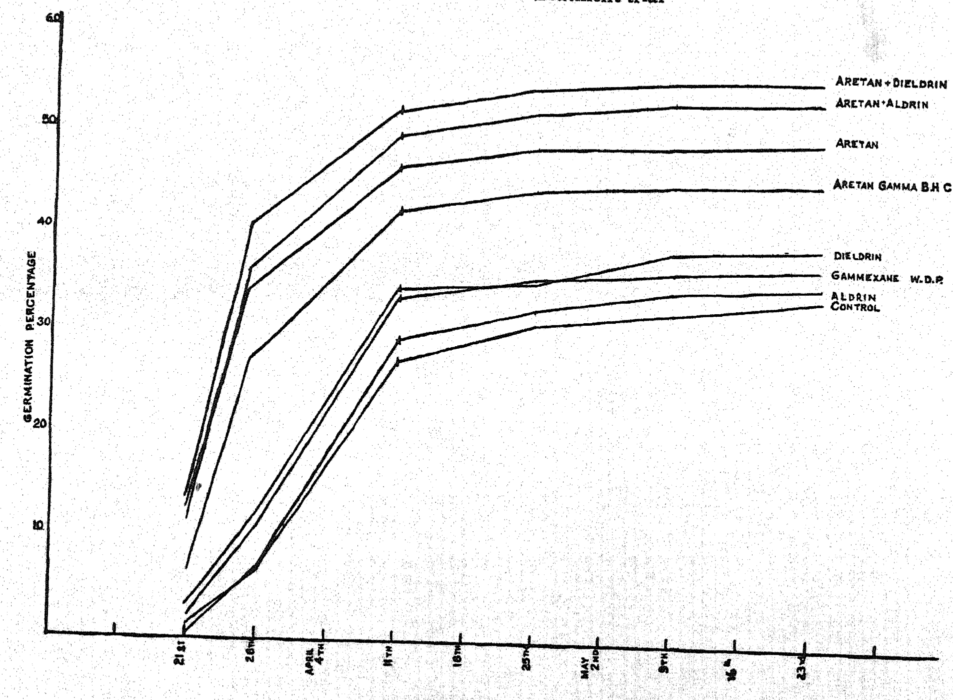
Collection of Data

The observations were recorded on the following basis:—

(1) *Germination:* Germination counts recorded at weekly intervals from the second week onwards till its completion. Total number of shoots in each sub-plot was counted and percentage of germination calculated.

(2) *Tillering:* Total number of tillers in July in each sub-plot was recorded. Tillers per clump were calculated by dividing the total number of tillers by final germination count. After harvest, one random

Fig. 1 Dual action seed treatment trial



row from each sub-plot was selected, dug out, and the stalks and number of clumps were enumerated and from these figures stalks per clump were calculated.

(3) *Growth Characters:* (a) The length of longest internode. (b) Linear development of cane. (c) Number of internodes and (d) number of arrowed stalks. One row of each sub-plot was selected at random harvested and above observations were recorded.

(4) *Incidence of termite attack in premonsoon, monsoon and post-monsoon periods:* In the case of premonsoon attack, incidence of termites in each sub-plot was examined on the basis of external symptoms only i.e., by complete enumeration of all the termite-attacked and healthy shoots of the entire sub-plot and calculating the percentage. In August (monsoon period) setts in the bare patches from two rows taken at random in each sub-plot were dug out and examined to record the percentage of germination failure caused by termite attack. After harvest, one row taken at random from each sub-plot was dug out completely and incidence of termite attack was recorded, examining each individual sett.

(5 *Total number of millable cane per plot.*

(6) *Final yield.*

Experimental Results

Germination: The effect of treatments on germination is presented in Table I and in Fig. 1.

Table I

Germination percentages at various intervals
(Mean values)

Date of Planting.—5-3-1956.   Variety.—B.O.17 (Slow germinator)

Treatments	Germination percentages after—					
	2 weeks	3 weeks	5 weeks	7 weeks	9 weeks	11 weeks
T1. Aretan	13·91	34·84	46·73	48·82	49·18	49·86
T2. Aretan-Gamma BHC	6·45	27·25	42·36	44·55	45·18	45·64
T3. Aretan/Aldrin	11·73	36·09	49·71	52·27	53·36	53·69
T4. Aretan/Dieldrin	13·55	40·56	52·11	54·45	55·37	55·76
T5. B.H.C.	2·18	11·07	33·38	35·73	36·56	37·33
T6. Aldrin	0·44	6·95	20·58	32·73	34·55	35·60
T7. Dieldrin	3·15	12·49	34·69	37·18	38·64	39·29
T8. Control	1·13	6·84	27·64	31·36	32·73	34·42
S.E.	1·07	1·44	1·24	1·35	1·38	1·36
C.D. at 5 per cent	3·11	4·16	3·60	3·91	4·01	3·95

The statistical analysis of the data shows the superiority of Aretan (T1) and Aretan/insecticide treatments (T2,T3 and T4) in accelerating the germination over control (T8) and insecticide treatments (T5,T6 and T7). The highest percentage of germination was obtained with Aretan/Dieldrin (T4), closely followed by Aretan/Aldrin (T3) and Aretan (T1), the first two showing an increase of more than 60 per cent over control. Aretan Gamma BHC (T2) was better than control and insecticide treatments only. The wide difference between Aretan/Dieldrin (T4) and Aretan/Gamma BHC (T2) in germination is noteworthy.

The germination after two weeks, obtained with Aldrin alone, was lesser than control but was found to improve subsequently and after 7 weeks it was slightly better than control, though the increase was not significant. It is probable that Aldrin may have some deleterious effect on the germination of eye buds. On the contrary, the germination under Dieldrin (T7) was significantly higher than control throughout and was slightly superior to other insecticide treatments (T5 and T6).

It is interesting to note that from the third week onwards highest germination was observed in T4 (Aretan/Dieldrin), closely followed by T3 (Aretan/Aldrin).

Tillering: The effect of treatments on the total number of tillers, tillers per clump at peak time of tillering, number of stalks per clump and number of millable canes at harvest is presented in Table II.

TABLE II

No. of tillers at peak time of tillering and stalk population at harvest (Mean values)

Treatments	At peak time (14-6-1956)		At harvest		Percentage of reduction in tillers
	Total no. of shoots per row	Tillers per clump	Total no. of stalks per row	Stalks per clump	
T1. Aretan	73·31	1·47	54·56	1·104	26·31
T2. Aretan-Gamma BHC	70 29	1·54	48·93	1·055	30·46
T3. Aretan/Aldrin	87·44	1·63	60·58	1·138	31·12
T4. Aretan/Dieldrin	89·98	1·61	57·55	1·032	36·35
T5. B.H.C.	58·94	1·58	46·62	1·246	22·19
T6. Aldrin	65·02	1·83	53·76	1·510	17·55
T7. Dieldrin	70·31	1·79	52·36	1·325	26·00
T8. Control	54·0	1·57	48·53	1·410	10·83
S.E.	5·14	...	1·76	0·04	...
C.D. at 5 per cent	14·89	N.S.	5·10	0·115	...

The largest number of tillers per row was observed in T4 (Aretan/Dieldrin) closely followed by T3 (Aretan/Aldrin) and both were significantly superior to all other treatments. T1 (Aretan), T2 (Aretan/Gamma BHC) and T7 (Dieldrin) showed superiority over 'control' and no significant differences could be observed among the insecticide treatments, although indications are in favour of T6 (Aldrin) and T7 (Dieldrin).

As regards tillers per clump at peak time, no significant differences could be observed between the various treatments. It is, however, interesting to note that the highest number of tillers per clump was observed in T6 (Aldrin) closely followed by T7 (Dieldrin). It may be inferred that tillering is not in proportion to germination. Tillering depends upon the room available (Stubbs, 1900) and this may partly explain the data recorded at peak time of tillering as regards tillers per clump. However, it may be noted that the average number of shoots per row was highest in T4 (Aretan/Dieldrin) closely followed by T3 (Aretan/Aldrin).

A perusal of the results showing stalk population per row at harvest reveals that differences due to treatments were statistically significant. It may be mentioned that except Aretan-Gamma BHC (T2), all other treatments have shown more number of stalk population than 'control' The increase was particularly striking in the case of T3 (Aretan/Aldrin) closely followed by T4 (Aretan/Dieldrin) and was more than nearly 20 per cent over 'control'.

It is interesting to note that differences in stalks per clump at harvest were also significant. T6 (Aldrin) alone showed superiority over all other treatments. The stalks per clump were found comparatively higher in insecticide treatments (T6,T5,T7) and control (T8). As has already been pointed out tillering was more in plots where there were more gaps due to poor germination and (probably) termite attack.

It is observed, there was reduction in stalk population at harvest, the percentage of reduction in stalks being highest in T4 (Aretan/Aldrin) followed by T3 (Aretan/Aldrin), comparatively less in insecticide treatments and lowest in 'control' where germination and tillering were the most inferior. It may be noted that the percentage of mortality in tillers was greater with greater population of shoots per row and it seems likely that there exists a positive correlation between the two. In spite of greater amount of mortality in T3 and T4, it is noteworthy that the stalk population was highest in T3, closely followed by T4.

Growth Characters: Observations were recorded with a view to find out whether these seed treatments have any influence on the growth of cane stalks (Tables III, IV and V).

TABLE III

Length of longest internode in Cms. at the time of harvest

Replications	Aretan	Aretan/ BHC	Aretan/aldrin	Aretan/ dieldrin	B.H.C.	Aldrin	Dieldrin	Control
I ...	13·2	12·0	12·8	13·5	11·8	12·8	12·9	12·3
II	13·5	10·6	13·8	13·5	13·0	13·0	11·2	11·1
III	13·5	13·1	13·4	13·7	13·4	12·8	13·5	12·2
IV	13·0	12·4	13·4	13·7	12·1	13·6	13·2	13·0
V	13·6	13·1	13·7	12·6	13·0	12·8	14·0	12·8
Mean ...	13·36	12·24	13·42	13·40	12·66	13·0	12·96	12·28
S.E. ...	0·286							
C.D. at 5 per cent	0·83							

The analysis of the data (Table III) reveals that T2 (Aretan-BHC) and T8 (control) were significantly inferior to T3(Aretan/Aldrin), T4 (Aretan/Dieldrin) and T1 (Aretan). There does not seem to exist any difference in the longest length of internode of cane among other treatments; however, indications are in favour of T6 (Aldrin) and T7 (Dieldrin).

Linear development of cane: The length of cane was measured and the data are presented in Table IV.

TABLE IV

Length of canes

Treatments	Canes over 9 ft.		Canes over 8 ft.		Canes over 7 ft.		Canes over 6 ft.		Total No. of canes in 5 rows
	No. of canes in 5 rows	Percentage	No. of canes in 5 rows	Percentage	No. of canes in 5 rows	Percentage	No. of canes in 5 rows	Percentage	
T1. Aretan ...	90	37·04	72	29·63	51	20·99	30	12·35	243
T2. Aretan-Gamma B.H.C.	49	23·79	42	20·39	68	33·01	47	22·82	206
T3. Aretan/Aldrin ...	100	40·32	63	25·40	64	25·10	21	8·47	248
T4. Aretan/Dieldrin ...	70	26·93	77	29·62	62	23·84	51	19·62	260
T5. B.H.C.	29	17·81	39	22·41	50	28·74	54	31·04	174
T6. Aldrin ...	92	40·71	50	22·12	48	21·24	36	15·93	226
T7. Dieldrin ...	52	24·53	66	31·13	59	21·83	35	16·51	212
T8. Control ...	44	22·33	45	22·84	61	30·97	47	23·86	197
S.E.	15·55								
C.D. at 5 per cent ...	45·05								

The analysis of the data on the number of millable canes over 9 ft. length, shows no significant difference between T3 (Aretan/Aldrin), T6 (Aldrin), T1 (Aretan) and T4 (Aretan/Dieldrin). However, it may be noted that either Aretan or Aldrin alone or their combination was superior to T5 (B.H.C.) and T8 (control). It may be pointed out that T4 (Aretan/Dieldrin) had resulted in an increase of more than 60 percent 9 ft. length of canes over that of control.

A perusal of the data with regard to the percentage of canes over 9 ft. length indicates that about 37 to 42 per cent millable canes was obtained in T1 (Aretan), T3 (Aretan/Aldrin) and T6 (Aldrin) whereas in T8 (control) only just over 20 per cent was obtained.

It may be noted that no significant difference was observed among the various treatments as regards the number of millable canes of 6 to 9 feet length.

It is noteworthy that the comparatively higher percentage of smaller canes (6 to 8 ft.) was under T2 (Aretan/BHC), T5 (BHC), and T8 (control) than under other treatments, signifying that growth was not influenced by T2 (Aretan Gamma BHC) and T5 (B.H.C.).

From the above, it may be inferred that seed treatment with either Aretan or Aldrin alone or their combination exerts a positive influence on the linear development of cane and this may be due to the protection to the setts and roots afforded by Aldrin against soil insects and by Aretan against fungal attack and also due to the latter's stimulating effect on germination of buds. It is also probable that inherent qualities of these chemicals may exert stimulating effect on stalk growth.

Number of internodes: The number of internodes in each millable cane was recorded and the results are presented in Table V.

TABLE V

Number of canes in 5 rows having different numbers of internodes at the time of harvest

Treatments	Canes having over 25 internodes		Canes having over 20-24 internodes		Canes having over 15-19 internodes		Canes having over 10-14 internodes		Total number of canes
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	
T1. Aretan ...	78	32·1	97	39·92	59	24·28	9	3·70	243
T2. Aretan B.H.C. ...	44	21·36	82	30·81	55	26·70	25	12·14	206
T3. Aretan/Aldrin	79	31·86	78	31·45	68	27·42	23	9·28	248
T4. Aretan/Dieldrin	71	27·31	100	38·47	66	24·39	23	8·85	260
T5. B.H.C. ...	31	17·81	79	45·40	45	25·86	19	10·92	174
T6. Aldrin ...	74	32·32	78	34·06	46	21·40	28	12·23	226
T7. Dieldrin ...	53	25·00	76	35·35	68	32·08	15	7·08	212
T8. Control ...	34	17·26	71	36·04	68	34·52	24	12·18	197
S.E.	12·00								
C.D. at 5 per cent ...	34·80								

The analysis of the data shows that canes having more than 25 internodes were significantly more in T3 (Aretan/Aldrin), T1 (Aretan), T6 (Aldrin)and T4 (Aretan/Dieldrin) than T5 (B.H.C.) and T8 (control).

As regards canes having below 25 nodes, no significant difference could be observed among the various treatments.

Arrowing: Field observations revealed conspicuous differences in arrowing among the various treatments and, therefore, it was felt that a study of the number of stalks that flowered might throw some light on the effect of seed treatment on flowering. The observations are presented in Table VI.

The analysis of the data shows that the number of arrowed stalks was significantly higher in T3 (Aretan/Aldrin) than in T2 (Aretan/BHC), T5 (BHC), T7 (Dieldrin) and T8 (Control), while T4 (Aretan/Dieldrin) was significantly superior to T7. Parthasarathy *et. al.* (1954) has reported that sucrose content of arrowed stalks is greater than that of unarrowed ones. One may, therefore, infer the possibility of getting good quality cane by seed treatment of setts. The greater mumber of arrowed stalks in T3 may probably be due to the prolonged growth period of stalks, a consequence of the quickness in germination, thereby reducing the time lag between planting and germination.

Incidence of Termite attack:- The observations of termite attack recorded at different periods are presented in Table VII.

TABLE VI

Number of arrowed stalks in a row measuring 33 ft. at the time of harvest

Replications	Aretan	Aretan/ B.H.C.	Aretan/ Aldrin	Aretan/ Dieldrin	B.H.C.	Aldrin	Dieldrin	Control
I	21	18	25	20	20	26	20	29
II	34	25	38	24	14	27	22	24
III	25	21	31	29	21	22	14	22
IV	24	24	26	24	21	39	14	24
V	20	10	20	34	28	18	16	20
Mean ...	24·8	21·4	28	26·2	20·8	24·4	17·2	22
S.E. ...	2·01							
C.D. at 5 per cent	5·82							

TABLE VII

Incidence of Termites (Mean values) at different periods

Treatments	Percentage of termite attacked shoots in June	Percentage of termite attack in August	Percentage of termite attack at harvest (December)
T1. Aretan	1·278	2·42	8·8
T2. Aretan/B.H.C.	2·553	7·87	26·8
T3. Aretan/Aldrin	0·742	...	...
T4. Aretan/Dieldrin	0·609	...	...
T5. B.H.C.	2·493	6·05	34·4
T6. Aldrin	0·369	...	...
T7. Dieldrin	0·676	...	...
T8. Control	1·128	8·79	37·2
S.E.	0·24	...	...
C.D. at 5 per cent	0·694	...	...

In the premonsoon period (June), the incidence (per cent mortality of shoots due to termites) was highest in T2 (Aretan/BHC), closely followed by T5 (BHC). It is interesting to note that these two chemicals have offered significantly less protection against the attack of termites than control and the mere fungicide compound, Aretan. It may be mentioned that T6 (Aldrin) was found to be significantly superior to all other treatments except T4 (Aretan/Dieldrin), T7 (Dieldrin) and T3 (Aretan/Aldrin).

The observations recorded during the monsoon (August) by examining the setts in patches reveal that the attack was highest in control closely followed by T2 (Aretan-B.H.C.) and T5 (B.H.C.). It is interesting to note the comparatively lesser incidence of termite attack in the case of T1 (Aretan). This is perhaps due to the stimulating and quickening effect of germination of eyebuds by this chemical, thereby escaping the initial mode of atttack by termites. It is noteworthy to observe that either T6 (Aldrin) or T7 (Dieldrin) alone or their combination with Aretan (T3 and T4) have given complete or thorough protection against termites. This is in conformity with the findings of Harbans Singh *et. al.* (1950) as regards Dieldrin.

At harvest, it is interesting to observe that the incidence of termite attack followed the same trend as in the monsoon period. The incidence continued to be highest in control, closely followed by T5 and T2. The

findings reported above are in conformity with the findings of Agarwala (1954) who reported the efficacy of Aldrin and Dieldrin in the control of termites.

It may be mentioned that at the time of harvest, the setts treated with either Aldrin (T6) or Dieldrin (T7) alone and their combination with Aretan (T3 and T4) were still green and not even touched by termites. It is interesting to note that T2, a compound containing both Aretan and B.H.C. failed to show its superiority over T1 (Aretan alone), which is only a fungicide. This may perhaps be due to the incompatability of B.H.C. with Aretan—probably both the chemicals losing their inherent nature.

The results clearly show that soaking setts in Aldrin or Dieldrin or their combinations with Aretan, provide an exceptionally good protection against termite attack.

Millable Canes:- The number of millable canes from each sub-plot is presented in Table VIII.

TABLE VIII

Number of millable canes in each sub-plot (1/40*th acre*)

Replications	Aretan	Aretan/ B.H.C.	Aretan/ Aldrin	Aretan/ Dieldrin	B.H.C.	Aldrin	Dieldrin	Control
I	553	453	550	582	376	584	517	623
II	629	452	707	665	559	635	508	500
III	551	604	681	622	505	543	581	505
IV	629	546	662	664	541	649	608	581
V	639	546	732	632	583	546	666	560
Mean ...	600	538	666	633	513	591·4	576	533·8
S.E.	19·37							
C.D. at 5 per cent	56·10							

A perusal of the data shows that the number of millable canes was highest in T3 (Aretan/Aldrin), followed by T4 (Aretan/Dieldrin), T1 (Aretan) and T6 (Aldrin). T3 was significantly superior to all other treatments, except T4. It is interesting to note that there is very little difference between T2 (Aretan-B.H.C.) and T8 (Control) while T5 (BHC) has given the lowest figure. However, no significant difference could be observed among these three treatments. It is not understood why T2 (Aretan/B.H.C.) failed to show its superiority at least over T8 (Control), since the compound contains equal quantity of Aretan used in T1, T3 and T4 and especially where the initial germination in T2 was significantly superior to that of control. It may probably be that B.H.C. depresses the stimulating effect of Aretan in the compound and affects the further growth of the stalk.

Yield:- The yield of each sub-plot in maunds is presented in Table IX.

It is seen that the highest yield was recorded in T3 (Aretan/Aldrin) closely followed by T4 (Aretan/Dieldrin), while T5 (BHC) has resulted in the lowest yield. It should, however, be noted that T3 was significantly superior to T1 (Aretan), T2 (Aretan-BHC), T5 (BHC), T7 (Dieldrin) and T8 (Control), while no significant difference was noted among T3, T4 and T6 (Aldrin). It is of interest to note that treatment T6 was significantly superior to T2 (Aretan-BHC), T5 (BHC) and control, in spite of the fact that the germination was considerably slow due to the deleterious effect of Aldrin E.C. It may, therefore, be inferred that even though the germination was slow due to Aldrin E.C., the protection offered by this chemical against soil insects is for a very considerable period. Very low mortality per cent of population as shown in Table No. II reinforces this point.

As regards T7 (Dieldrin) which shows beneficial effect on germination, the yield is, however, disappointing and is only on par with the control. The stimulating effect of T4 (Aretan/Dieldrin) and T7 (Dieldrin) had not been proportionately reflected in the ultimate yield, as can be seen from the figures. It may be that the dosage of Dieldrin used was low or the protection and the stimulating effect offered by this chemical is only temporary.

No significant differences were, however, noted among T2, T5, and T8. As pointed out earlier, BHC, while it may be incompatible with Aretan, might have an adverse effect on roots and consequently on

growth, as evidenced by fewer stunted roots in the setts treated with B.H.C. The observations are in conformity with the findings of Agarwala *et. al.* (1954). It may be inferred that Aretan-Gamma-BHC seed treatment is not beneficial in increasing the yield and controlling soil insects.

Table IX

Yield in maunds of each sub-plot (1/40*th acre*)

Replications	T1	T2	T3	T4	T5	T6	T7	T8
	Aretan	Aretan/ B.H.C.	Aretan/ Aldrin	Aretan/ Dieldrin	B.H.C.	Aldrin	Dieldrin	Control
I	10·83	9·02	10·79	12·31	8·59	10·78	9·17	10·05
II	13·15	9·67	15·57	13·88	10·00	14·27	10·72	9·94
III	11·38	12·18	13·61	14·10	9·92	11·85	11·46	9·28
IV	11·68	10·05	15·39	13·15	10·34	14·91	12·54	12·02
V	13·27	11·75	13·71	12·95	12·22	11·34	12·89	12·00
Mean ...	12·06	10·52	13·81	13·28	10·21	12·63	11·36	10·66
S.E. ...	0·71							
C.D. at 5 per cent	1·45							

Conclusion

The results clearly indicate the beneficial effect of dipping setts for 10 minutes in Aretan/ Aldrin and Aretan/Dieldrin solution at the dosage used for hastening germination, improving growth, increasing the number of millable canes, yield and giving protection to setts against soil insects and fungal attack throughout the life period of the crop.

Further work is in progress to find out the optimum dose of these combinations both in wettable powder and emulsion forms and to evolve a suitable formulation of Aldrin and Dieldrin for easy handling and distribution to growers.

Summary

With a view to study the effects of organo-mercury fungicide/insecticide compounds, namely Aretan, Aretan-Gamma BHC., Aldrin, Dieldrin, BHC, Aldrin/Aretan, Aretan/Dieldrin, on germination, tillering, growth, incidence of termite attack and yield, an experiment was carried out on field scale in randomised blocks at Marhowrah(Bihar) with B.O.17 cane during 1955-56 season and the findings are presented and discussed.

The setts were steeped in the respective solutions for about 10 minutes and then planted in the furrows.

Observations on germination at various intervals, tillering, growth characters, damage by termites, number of millable canes and yield at harvest brought out the following :—

(1) Treatment of setts before planting with Aretan/Dieldrin (T4), Aretan/Aldrin (T3), Aretan (T1) and Aretan/BHC (T5) improved germination in the order of the treatments.

(2) Tillering was highest in Aretan/Aldrin and Aretan/Dieldrin.

(3) Treating setts with Aretan/Aldrin and Aretan/Dieldrin influenced growth, by increasing the number of nodes, increasing the length of cane and hastening maturity as evidenced by arrowing.

(4) Aldrin and Dieldrin and their combinations with Aretan provided exceptionally good protection throughout the life of the crop against the attack of termites. Treatments with BHC and Aretan-BHC were found to be no better than control in offsetting the incidence of termites.

(5) The number of millable canes was highest in Aretan/Aldrin, followed by Aretan/Dieldrin, Aretan and Aldrin.

(6) As regards yield, Aretan/Aldrin was significantly superior to Aretan, Aretan/BHC, Dieldrin and control, while no significant difference was noted with Aretan/Aldrin, Aretan/Dieldrin and Aldrin.

Recommendation

It is recommended that cane setts, before planting, be steeped in solution containing ½lb 3 per cent Aretan or Agallol+0·2 lb. actual Aldrin in 10 gallons of water for at least 10 minutes. This treatment, apart from stimulating germination in slow germinators, will also be helpful for medium germinators. It may be necessary for badly termite-infested fields and light soils, that additional quantity of Aldrin (0·5 to 0·8 lb. actual per acre) should be applied in the furrows either in the form of emulsion as spray or dust with fertilizer, apart from the seed treatment given.

Acknowledgments

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STUDIES ON THE POST-EMBRYONIC DEVELOPMENT OF *APANTELES FLAVIPES* CAM. (BRACONIDAE-HYMENOPTERA), A PARASITE OF SUGARCANE STEM BORERS IN INDIA

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INTRODUCTION

OF the different pest control measures commonly practised biological control is not only a permanent means of pest repression (Imms, 1937) but also economic in the long run. The various natural parasites of sugarcane borers are, therefore, potentially useful in this context. *Apanteles flavipes* Cam. is a common endoparasite of the sugarcane stem borer larva, and the present paper incorporates the results of laboratory investigations undertaken at the Sugarcane Research Institute, Bihar, Pusa, during 1955 to study its general biology and the influence of prevailing temperature and humidity conditions on its development. As seasonal fluctuations influence the ecological balance between host and parasite relationship, their proper appreciation might lead to a better and efficient utilisation of the parasite under reference in the biological control of stem borers.

Apanteles flavipes is commonly available not only in Bihar but in all the sugarcane-growing tracts of India. It is observed to have a wide host-range (Bhatnagar, 1948) covering most of the stem borer species, e.g., *Chilotraea*, *Diatraea*, *Chilo* and *Sesamia* sp., infesting sugarcane, maize, jowar, and wild saccharums. This parasite was originally described by Cameron (1891) from Poona. Since then it was reported from various parts of the country.

MATERIAL AND METHOD

The host materials were the third instar larvae of *Chilotraea*, *Diatrae*, *Chilo*, and *Sesamia* sp., as the parasites were observed to prefer well-developed hosts. The larvae used in the experiment were all reared in the laboratory to ensure that they were unparasitised. Before offering these hosts for parasitisation, they were unparasitised. Before offering these hosts for parasitisation, they were anaesthetized with chloroform for about a minute and then removed to glass jars in which freshly-emerged parasites had been released. The top of these jars were covered with muslin cloth. The parasites with their hosts were left undisturbed for 24 hours, after which the introduced larvae expected to have been parasitised, were removed and each maintained separately on saccharum pieces. The cocoons developing from parasitised larvae were transferred to specimen tubes, each 4″×1″, for parasite emergence. The emerged parasites were further utilised for parasitising another set of freshly anaesthetized larvae, and this process continued throughout the period of studies.

Observations were also recorded in respect of the development period of the parasite from egg to grub stage, total period spent as cocoon and the sex ratio of the adults developing from each cluster of cocoon. The daily temperature and humidity records were taken with the help of maximum and minimum and dry and wet bulb thermometers.

RESULTS AND DISCUSSION

(a) *General Biology*

Observations on the parasitised larvae recorded every day, indicated that the grub period of the parasite fluctuates from 7 to 23 days according to temperature and humidity variations during June to November months. When the full-grown parasitic grubs (Fig. 1) are about to pupate, they usually puncture the ventro-lateral portion of the host's body through which they come out. The host at this stage becomes inactive and incapable of feeding. They are observed to remain alive in this condition up to two weeks. The emergence hole of the grub on its host's body later on turns black.

The emerging grubs immediately spin closely-knit silken white cocoons (Fig. 2) within which they pupate. The pupal period ranges from five to seven days. The adults emerge mostly in the early hours of

FIG. 1 Grubs.

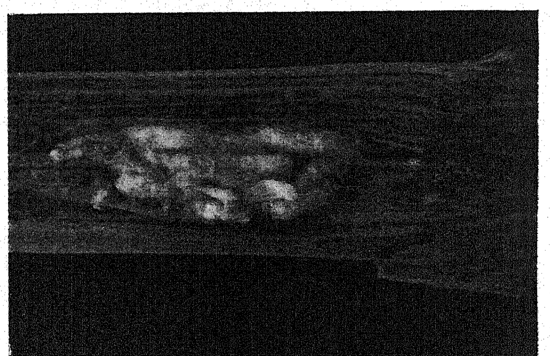


FIG. 2 Cocoon.

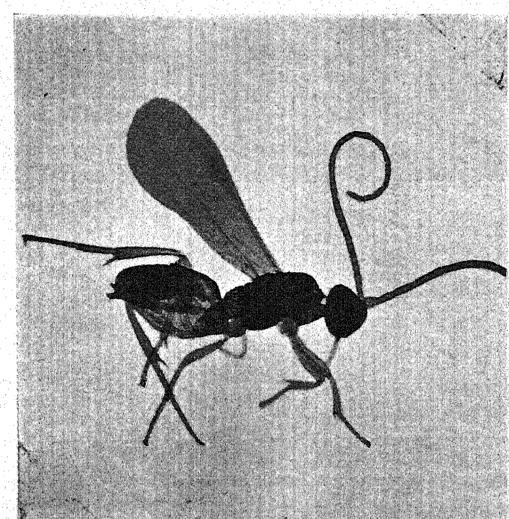


FIG. 3 Adult female.

the morning, and the male and female adults copulate immediately thereafter. The maximum number of parasites developing from a cluster of cocoon was 84, the average sex ratio being 3:1 : : ♀:♂ during the observational period. The average longevity of adults (Fig. 3) was observed to be about three days without food. Under similar sets of conditions there was no difference in the development period of the various stages of the parasites reared on different host species.

Under field conditions in Bihar, *Apanteles flavipes* is observed to occur from April to November (1955) which synchronises with the period of availability of its host, the sugarcane stem-boring larva. Regular collections made at Pusa farm indicated a low incidence (two to three per cent) of field parasitisation from April to June reaching a maximum of about 16·9 per cent during September when host population was also seen to be high. This poor field parasitisation may be mainly attributed to the meteorological factors, which are probably not very conducive to quick development of the parasites, and their low dispersal capacity since superparasitism, another important factor governing ultimate parasite population in nature, is not a common phenomenon in the State. The authors have reared the parasites in the natural conditions of the laboratory from May till November and it is, therefore, felt that they can be successfully cultured on mass scale under favourable controlled conditions and released in the field for stem borer control. Work in this connection is under progress on the lines indicated by Narayanan *et al.* (1953).

(b) *Grub period in relation to temperature and humidity variations*

It was noted that the grub period was influenced mainly by temperature and humidity variations. Observations on daily temperature (maximum and minimum). humidity and grub period were, therefore, recorded for the 32 specimens under examination and have been presented in Table I. Average of daily maximum and minimum temperatures and humidity for the corresponding periods have been shown in columns 4, 5, and 6 of the table.

TABLE I

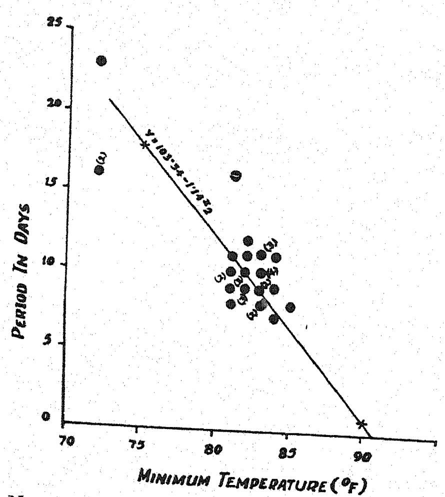
Specimen	Period	No. of days	Max. Temp.	Min. Temp.	Humidity Per cent
1.	9/6 – 19/6	11	88	83	79
2.	9/6 – 16/6	8	88	85	77
3.	12/6 – 23/6	12	87	83	82
4.	12/6 – 21/6	10	87	82	81
5.	12/6 – 21/6	10	87	82	81
6.	12/6 – 21/6	10	87	82	81
7.	13/6 – 22/6	10	87	82	81
8.	13/6 – 21/6	9	87	82	81
9.	15/6 – 23/6	9	86	83	84
10.	28/6 – 8/7	11	86	83	87
11.	28/6 – 7/7	10	86	83	87
12.	28/6 – 7/7	10	86	83	87
13.	28/6 – 8/7	11	86	83	87
14.	29/6 – 7/7	9	86	83	87
15.	29/6 – 8/7	10	86	83	87
16.	8/7 – 16/7	9	86	82	87
17.	8/7 – 17/7	10	86	81	88
18.	15/7 – 30/7	16	85	81	89
19.	15/7 – 25/7	11	85	81	89
20.	16/7 – 23/7	8	85	81	89
21.	23/7 – 31/7	9	86	82	89
22.	10/8 – 18/8	9	84	81	90
23.	10/8 – 19/8	10	84	81	90
24.	29/8 – 6/9	9	87	84	84
25.	29/8 – 4/9	7	87	84	84
26.	7/9 – 14/9	8	84	83	86
27.	7/9 – 14/9	8	84	83	86
28.	24/9 – 4/10	11	87	84	85
29.	2/10 – 12/10	11	85	82	84
30.	5/11 – 27/11	23	76	72	75
31.	5/11 – 20/11	16	76	72	73
32.	5/11 – 20/11	16	76	72	73

From the data of this table estimates of total correlation coefficients have been calculated between (1) grub period on the one hand and (2) maximum temperature, (3) minimum temperature and (4) humidity percentage on the other, and are given below:—

$r_{12} = -0{\cdot}7468^{**}$ $r_{13} = -0{\cdot}8157^{**}$ $r_{14} = -0{\cdot}5064^{**}$

FIG. 4

Showing Relationship between Minimum Temperature and Grub Period.



Note :—Figures in parenthesis denote number of frequencies.

It will be seen that all the total correlation coefficients have come out negative and are significant at one per cent level, indicating thereby that maximum temperature, minimum temperature and humidity have influence on the grub period, the higher temperature (or humidity) favouring early formation of cocoon.

The three partial correlation coefficients have also been calculated and the values are —

$r_{12\cdot34} = -0\cdot1222$ $\qquad r_{13\cdot24} = -0\cdot4596^{**}$ $\qquad r_{14\cdot23} = -0\cdot0400$

It is now seen that only the partial correlation coefficients between grub period and minimum temperature, when the other two meteorological factors are kept constant, is significant. The multiple correlation coefficient between the period of cocoon formation and the three meteorological factors have worked out to R=0·8405 which is significant at one per cent level. The degree of improvement in the prediction equation by addition of the two variables, namely maximum temperature and humidity, has been statistically tested, the result of which is given in Table II.

TABLE II

Analysis of variance

Due to regression	DF	S.S.	M.S.S.	F.
X_2	1	202·94	202·94	63.46**
X_1—X_3	2	12·53	6·27	1·96 N.S.
Deviation from regression	28	89·53	3·20	

It will be noticed that the contribution due to maximum temperature and humidity has come out non-significant indicating that the grub period is solely dependent upon minimum temperature, the relationship between the two being linear within the range of variation in minimum temperature available in the data (72° to 85°F.).

The equation has worked out as follows:—

$$Y = 103\cdot34 - 1\cdot14X_2,$$

Where Y stands for grub period and X_2 for minimum temperature. The percentage of total variation accounted for by minimum temperature (X_2) is 66·54 per cent. The straight line has also been represented graphically in Fig. 4, with the observed values denoted by dots.

The results of this study, therefore, indicate that variation in the three meteorological factors do not affect the cocoon period which is almost constant (five to seven days) from June to November, but the grub period appears to be associated with the minimum temperature, an increase in the latter being followed by a reduction in the former. The grub period is minimum when minimum temperature reaches about 85°F.

Summary

1. Laboratory studies were undertaken at the Sugarcane Research Institute, Pusa, Bihar, during 1955 to observe, besides general biology, the influence of prevailing temperature and humidity on the growth of *Apanteles flavipes* Cam., a common endo-parasite of sugarcane stem-boring larvae.

2. The grub period of the parasite was observed to fluctuate from 7 to 23 days and the cocoon period from five to seven days during June to November months. The average sex ratio of the adult parasites was recorded to be 3:1::♀:♂ during the observational period and their longevity about three days.

3. Total correlation coefficients calculated between grub period on one hand and maximum temperature, minimum temperture and humidity on the other were found to be significant at one per cent level.

4. Estimates of partial correlation cœfficients were also worked out and the results showed that the grub period was influenced only by the prevailing minimum temperature range (72°–85° F.).

5. Variations in the three meteorological factors, i.e., maximum temperature, minimum temperature and humidity, however, do not appear to affect the cocoon period which is almost constant (five to seven days) from June to November.

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ON THE OCCURRENCE OF WEEDS IN SUGARCANE FIELDS AS INFLUENCED BY CONTINUOUS APPLICATION OF FERTILISERS TO SOIL

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Introduction

EARLIER workers have observed that the application of different fertiliser treatments and the different pH ranges of the soils may be favourable to the growth of certain weed species while they may suppress the others. 't Hart (1948) opined that potassium application on grass land encouraged *Poa trivialis* and *Phleum pratense*, while the *proportion* of *Poa pratensis* and *Agrostis stolonifera* was reduced. Rich and Odland (1947), concluded that potash affected the botanical compositon of grass-legume hay and that a reduction of potash from 100 to 50 lbs. per acre lowered the proportion of legume from 50 to 3 per cent. Sherwood *et. al.* (1947) observed that the application of limestone and phosphate on pasture herbage stimulated the growth of blue grass and that while clover was more responsive to phosphate, Lespedeza responded more to limestone. Homes (1949) saw that heavy nitrogenous manuring encouraged such grasses as *Lolium perenne* and *Dactylis glomerata* while reducing the amounts of poorer grasses, clovers and dicotyledonous weeds in general. Suppression of clover by the application of N has been observed in Sweden as well (1949). According to Sonneveld (1947) nitrogen application greatly discouraged *Agrostis stolonifera* and that the heavier the doses, the smaller was the proportion of *Agrostis*.

Nielsen (1947) observed pH 7·0 to 7·5 as the most favourable for the growth of lucerne. Djjakova (1948) while studying the causes of failure of clover sowings on acid soils observed that the cause was not only the increased content of hydrogen ions in the same soil, but also the high exchangeable acidity conditioned by increased content of mobile aluminium. Kelly (1947) also found pH 7·0 to 8·3 to be best suited for the growth of clover and lucerne.

Albrecht (1948) observed *Andropogon virginicus* to be a plant indicator of decline in soil fertility and on experimental plots in Missouri, according to him, it took charge of continuous timothy grass plots kept unmanured for 60 years but did not oust manured timothy. Costa and d'Oliveira (1943) while studying the value of natural vegetation in making soil surveys have noted *Agrostis truncatula* to be abundant in poor fallow land. Colonisation of land by *Harmal* (*Peganum harmala*), *AK* (*Calotropis procera*), *Serkanda* (*Saccharum munja*) and *Lani* (*Suaeda fruticosa*) according to Hoon and Dhawan (1950) are associated with progressive stages of soil deterioration. Bharucha and Dubash (1951) classified the nitrophilous plants of Bombay, observing that certain plants are nitrate positive while others are definitely nitrate negative. This amply shows that the abundant occurrence or luxuriant growth of certain species in certain localities and their absence or poor growth in other can give some indication of the chief soil conditions prevailing there.

With this end in view, it was thought desirable to see whether changes brought about in the pH or other characteristics of the soil by the application of different fertiliser treatments over a number of years, had any effect on the occurrence of weeds.

Material and Methods

The present paper is based on observations recorded in the plots of a long-term NPK fertiliser experiment which has been in progress at the Main Sugarcane Research Station, Shahjahanpur, U.P., India. This experiment is conducted on sugarcane in two fields which are alternately cropped and fallowed. The fertiliser treatments are 27 combinations of (N_0, N_1 and N_2) $\times$ (P_0, P_1 and P_2) $\times$ (K_0, K_1 and K_2) replicated four times, the doses being 0,100 and 200 lb. of N as ammonium sulphate, 0, 75 and 150 lb. of P_2O_5 as double superphosphate and 0, 75 and 150 lb. of K_2O as potassium sulphate per acre respectively. For the last sixteen years, each of the ($27\times4=$) 108 plots of the experiment has been receiving the same fertiliser applications every alternate year when the field is cropped. Observations on weed occurrence were recorded in 48 plots belonging to the combinations of (N_0, N_1, N_2) $\times$ (K_0, K_1, K_2) $\times$ (P_0, P_2) in four replications. The weeds occurring in the different plots were observed at monthly intervals and their frequency of occurrence has been recorded. The relative population of weeds in the plots has been estimated in three degrees viz., abundant, moderately frequent and occasional. In all, about 55 weeds were recorded (Appendix I).

FINDINGS AND DISCUSSION

Effect of continuous application of ammonium sulphate on weed occurrence under fallow conditions: Observations were started from the month of March, 1950 soon after the sugarcane crop had been harvested. In each N treatment, there were 16 plots, i.e. four plots in each of the four replications. Table I and figure 1 show the differential occurrence of weeds under fallow conditions in the 3N doses in combination with K_0, K_2 and P_0, P_2 treatments.

TABLE I.

*Showing the occurrence of weed species in plots out of total number observed (16) in N_0, N_1 and N_2 series in field lying fallow during 1950**.

Treatments	N_0									N_1									N_2								
Time of observation	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.
1. *Chenopodium album*, Linn. ...	...	3	1	...	...	...	Observation not recorded	...	...	2	8	5	6	...	...	Observation not recorded	...	...	8	13	12	9	...	...	Observation not recorded	...	...
2. *Sida* sp. ...	...	1	2	...	...	...		...	1	...	1	2	3	2	1		3	3	...	5	8	5	4	5		5	4
3. *Polygonum plebejum*, R. Br. ...	...	...	...	...	...	...		...	...	...	1	1	3	...	...		...	...	...	6	9	8	...	...		...	...
4. *Portulaca oleracea*, Linn. ...	...	...	...	...	1	...		...	...	...	...	...	...	5	...		...	...	...	...	...	...	3	...		...	...
5. *Commelina benghalensis*, Linn. ...	...	...	...	...	...	1		1	...	...	...	...	...	3	5		9	5	...	...	...	...	6	9		7	6
6. *Physalis minima*, Linn. ...	...	...	...	...	...	2		3	4	...	...	...	...	...	8		12	10	...	...	...	...	...	10		8	9
7. *Jussieua suffruticosa*, Linn. ...	...	...	...	...	...	...		2	1	...	...	...	...	...	...		...	...	...	...	...	...	...	...		7	6
8. *Ammannia baccifera*, Linn. ...	...	...	...	...	...	...		5	7	...	...	...	...	...	...		3	4	...	...	...	...	...	...		4	8
9. *Celosia argentea*, Linn. ...	...	...	...	...	...	...		3	2	...	...	...	...	...	...		3	7	...	...	...	...	...	...		4	6
10. *Desmodium triflorum*, DC. ...	9	11	14	16	16	16		16	16	2	9	9	9	5	6		5	6	11	...	1	3	1	4		5	1
11. *Alysicarpus vaginalis*, DC. ...	...	...	...	...	3	7		8	6	...	...	...	...	...	...		...	...	...	...	...	...	...	...		...	...
12. *Aeschynomene indica*, Linn. ...	...	...	...	...	...	...		3	...	...	...	...	...	...	4		...	...	...	...	...	...	...	...		...	...
13. *Vicoa auriculata*, Cass. ...	...	...	...	...	...	...		9	15	...	...	...	...	...	...		10	13	...	...	...	...	...	...		1	3
14. *Striga euphrasioides*, Benth. ...	...	...	...	...	...	...		3	2	...	...	...	...	...	...		...	...	...	...	...	...	...	...		...	...

*Figures denote the number of plots in which respective weeds occurred.

From the table we see that during the pre-monsoon period (March to June) *Chenopodium album, Sida* sp. and *Polygonum plebejum,* occurred more in N_2 plots than in N_1. These weeds as a rule did not occur in the N_0 plots, and even if they occasionally did, their growth was observed to be poor and not so rank as in N_2 plots. *Chenopodium album,* occurred in April in 13 of the N_0 plots as against only 3 of N_0 plots. From May onwards having completed its life cycle. *Chenopodium album* began to die down, till in July it was no more to be seen. *Polygonum plebejum* was not seen after July.

Desmodium triflorum on the contrary occupied N_0 plots both during the pre-monsoon and post-monsoon periods, the rains helping it to spread out and grow in abudance. Thus from June onwards *Desmodium triflorum* was seen occurring in abundance in all the plots of the N_0 series. On the other hand, it did not thrive well in N_1 and N_2 plots, its presence in the latter being very infrequent.

With the onset of rains i.e., from July onwards more species began to come up. Of these, *Commelina benghalensis* and *Physalis minima* tended to occur more in the N_2 and N_1 plots than in the N_0 plots where their presence was only occasional. *Alyiscarpus vaginalis,* however, occurred frequently in six to eight plots of N_0 series, being completely absent from N_1 and N_2 series.

The beginning of the cold season marked the appearance of certain other species of weeds. Of these *Vicoa auriculata* started coming up more frqeuently in the N_0 and N_1 plots than in N_2 plots where its presence

	N_0				N_1				N_2			
1. *Chenopodium album*	P	-	-	-	P	P	-	-	P	P	P	P
	P	-	-	-	P	P	-	-	P	P	P	-
	P	-	-	-	P	P	-	-	P	P	P	-
	-	-	-	-	P	P	-	-	P	P	P	-
2. *Sida sp.*	P	-	-	-	PP	-	-	-	PP	P	-	-
	P	-	-	-	PP	-	-	-	PP	P	-	-
	-	-	-	-	PP	-	-	-	PP	P	-	-
	-	-	-	-	-	-	-	-	PP	P	-	-
3. *Polygonum plebejum*	-	-	-	-	P	-	-	-	P	P	P	-
	-	-	-	-	P	-	-	-	P	P	-	-
	-	-	-	-	P	-	-	-	P	P	-	-
	-	-	-	-	-	-	-	-	P	P	-	-
4. *Portulaca Pleracea linn.*	P	-	-	-	P	P	-	-	P	-	-	-
	-	-	-	-	P	-	-	-	P	-	-	-
	-	-	-	-	P	-	-	-	P	-	-	-
	-	-	-	-	P	-	-	-	-	-	-	-
5. *Commelina benghalensis*	P	-	-	-	PP	PP	PP	-	PP	PP	PP	-
	-	-	-	-	PP	PP	-	-	PP	PP	-	-
	-	-	-	-	PP	PP	-	-	PP	PP	-	-
	-	-	-	-	PP	PP	-	-	PP	PP	-	-
6. *Physalis minima*	P	-	-	-	PPP	PPP	PPP	-	PPP	PPP	PPP	-
	P	-	-	-	PPP	PPP	PPP	-	PPP	PPP	PPP	-
	P	-	-	-	PPP	PPP	PPP	-	PPP	PPP	-	-
	P	-	-	-	PPP	PPP	PPP	-	PPP	PPP	-	-
7. *Jussieua suffruticosa*	P	-	-	-	-	-	-	-	PP	PP	-	-
	P	-	-	-	-	-	-	-	PP	PP	-	-
	-	-	-	-	-	-	-	-	PP	PP	-	-
	-	-	-	-	-	-	-	-	PP	-	-	-
8. *Celosia argentea*	P	-	-	-	P	P	-	-	PP	PP	-	-
	P	-	-	-	P	P	-	-	PP	PP	-	-
	P	-	-	-	P	P	-	-	PP	-	-	-
	-	-	-	-	P	-	-	-	PP	-	-	-
9. *Ammannia baccifera*	PP	PP	-	-	PP	-	-	-	PPP	PPP	-	-
	PP	PP	-	-	PP	-	-	-	PPP	PPP	-	-
	PP	PP	-	-	PP	-	-	-	PPP	PPP	-	-
	PP	-	-	-	PP	-	-	-	PPP	PPP	-	-
10. *Desmodium triflorum*	PPP	PPP	PPP	PPP	P	P	P	-	P	P	-	-
	PPP	PPP	PPP	PPP	P	P	-	-	P	-	-	-
	PPP	PPP	PPP	PPP	P	P	-	-	P	-	-	-
	PPP	PPP	PPP	PPP	P	P	-	-	P	-	-	-
11. *Alysicarpus vaginalis*	PP	PP	-	-	-	-	-	-	-	-	-	-
	PP	PP	-	-	-	-	-	-	-	-	-	-
	PP	PP	-	-	-	-	-	-	-	-	-	-
	PP	PP	-	-	-	-	-	-	-	-	-	-
12. *Aeschynomene indica*	P	-	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
13. *Vicoa auriculata*	PP	PP	PP	PP	PP	PP	PP	PP	P	-	-	-
	PP	PP	PP	PP	PP	PP	PP	-	P	-	-	-
	PP	PP	PP	PP	PP	PP	PP	-	P	-	-	-
	PP	PP	PP	-	PP	PP	PP	-	-	-	-	-
14. *Striga euphrasioides*	P	-	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-

PPP to a plot: Weed occurred in abundance
PP to a plot: Weed occurred in moderate frequency
P to a plot: Weed occurred occasionally.

FIG. 1. Showing relative maximum population of weeds in number of plots out of total number examined (16) under the different N treatments in the field lying fallows in 1950

was somewhat rare. *Striga euphrasioides* which was seen only in one replication, also occupied only the N_0 plots. In the N_1, N_2 series of the same replication, it was conspicuous by its complete absence.

Effect of continuous application of ammonium sulphate on weed occurrence under cropped conditions: Observations in the field of standing sugarcane crop could not be taken before August, as frequent hoeings and other cultural operations interfered with the growth of weeds and the observations to be taken on them. After the rains, however, the weeds got an impetus and different species started growing freely, in certain cases vigorously.

TABLE II.

*Showing the occurrence of weed species in plots out of total number observed (16) in the N_0, N_1 and N_2 series in the field having sugarcane during 1950 crop**

Treatments	N_0				N_1				N_2			
Time of observation	Aug.	Sep.	Oct.	Nov.	Aug.	Sep.	Oct.	Nov.	Aug.	Sep.	Oct.	Nov.
1. *Sida* sp.	2	6	10	9	6	4	7	7	6	8	8	7
2. *Physalis minima*, Linn.	2	7	9	7	8	7	6	5	9	10	11	10
3. *Commelina benghalensis*, Linn.	2	1	1	...	13	13	13	12	9	8	8	6
4. *Desmodium triflorum*, DC.	15	14	13	14	3	2	6	5	3	4	...	1
5. *Alysicarpus vaginalis*, DC.	14	14	13	15	5	4	3	4	3	2	1	2
6. *Rhynchosia minima*, DC.	5	3	5	6	1	...	1	...	...	...	...	...
7. *Indigofera hirsuta*, Linn.	6	6	6	5	...	2	1	1	1	1	1	1
8. *Aeschynomene indica*, Linn.	2	8	4	1	...	2	...	...	1	1	...	2
9. *Cassia tora*, Linn.	...	4	2	1	...	1	1	1	...	...	...	...
10. *Vicoa auriculata*, Cass.	...	10	11	13	...	4	10	11	...	2	4	3
11. *Ammannia baccifera*, Linn.	...	...	8	6	...	...	1	...	...	...	2	1
12. *Phyllanthus simplex*, Retz.	...	4	4	5	...	...	...	...	...	...	...	...
13. *Alysicarpus bupleurifolius*, DC.	...	5	10	7	...	...	...	...	...	...	...	...
14. *Striga euphrasioides*, Benth.	4	4	4	3	...	...	...	...	...	...	...	...

*Figures denote the number of plots in which the respective weeds occurred.

The observations in the different treatments recorded in Table II and Fig. 2 show that in the cropped plots many species exhibit the same trend as in the corresponding plots under fallow conditions. *Commelina benghalensis* was found more frequently in the N_1 and N_2 plots as compared to the N_0 where its presence was only occasional. *Physalis minima* and *Sida* sp., however, did not show an marked treatmental response in their occurrence. *Desmodium triflorum* and *Alysicarpus vaginalis* throve better in the N_0 plots and occurred frequently in 13 to 15 plots. In the N_1 and N_2 series they occurred only occasionally in a few plots here and there. *Indigofera hirsuta* was also seen occurring frequently in six of the N_0 plots as against its occasional occurrence in one of the N_2 plots. In N_1 plots its presence was only sporadic; it was met with in only one of two plots. Another species, *Alysicarpus bupleurifolius* was seen occurring frequently from September onwards in five to ten of the N_0 plots, being completely absent from the N_1 and N_2 series. *Rhynchosia minima, Aeschylnomene indica, Cassia tora* and *Phyllanthus simplex* were seen in some of the plots only; but even then they exhibited a preference for the N_0 plots, being either absent or growing poorly in the N_1 and N_2 plots.

As in the uncropped field, *Striga euphrasioides* occurred in the fourth replication and only in the N_0 plots of it. In these plots, it was found in abundance whereas in the N_1 and N_2 series it was completely absent. The two fields fallow and the cropped are situated side by side with a *pucca* water channel in-between, and in both, the 4th replication lies at the extreme end of the fields, which also marks the boundary of the farm. It is possible that the seeds of *Striga* got dispersed from the vegetation outside the farm boundary and could reach only one replication of the experiment during the year of obsrevations. The situation of the plots alone, however, does not explain the occurrence of the weed in the N_0 plots exclusively; this latter can be attributed

	N_0				N_1				N_2			
1. *Sida sp.*	P	P	P	–	PP	PP	–	–	PP	PP	–	–
	P	P	P	–	PP	PP	–	–	PP	PP	–	–
	P	P	–	–	PP	PP	–	–	PP	PP	–	–
	P	P	–	–	PP	–	–	–	PP	PP	–	–
2. *Physalis minima*	P	P	P	–	P	P	–	–	P	P	P	–
	P	P	–	–	P	P	–	–	P	P	P	–
	P	P	–	–	P	P	–	–	P	P	P	–
	P	P	–	–	P	P	–	–	P	P	–	–
3. *Commelina benghalensis*	P	–	–	–	PPP	PPP	PPP	PPP	PP	PP	PP	–
	P	–	–	–	PPP	PPP	PPP	–	PP	PP	–	–
	–	–	–	–	PPP	PPP	PPP	–	PP	PP	–	–
	–	–	–	–	PPP	PPP	PPP	–	PP	PP	–	–
4. *Desmodium triflorum*	PP	PP	PP	PP	P	P	–	–	P	–	–	–
	PP	PP	PP	PP	P	P	–	–	P	–	–	–
	PP	PP	PP	PP	P	–	–	–	P	–	–	–
	PP	PP	PP	–	P	–	–	–	P	–	–	–
5. *Alysicarpus vaginalis*	PP	PP	PP	PP	P	P	–	–	P	–	–	–
	PP	PP	PP	PP	P	–	–	–	P	–	–	–
	PP	PP	PP	PP	P	–	–	–	P	–	–	–
	PP	PP	PP	–	P	–	–	–	–	–	–	–
6. *Alysicarpus bupleurifolius*	PP	PP	PP	–	–	–	–	–	–	–	–	–
	PP	PP	PP	–	–	–	–	–	–	–	–	–
	PP	PP	–	–	–	–	–	–	–	–	–	–
	PP	PP	–	–	–	–	–	–	–	–	–	–
7. *Rhynchosia minima*	PP	PP	–	–	P	–	–	–	–	–	–	–
	PP	PP	–	–	–	–	–	–	–	–	–	–
	PP	–	–	–	–	–	–	–	–	–	–	–
	PP	–	–	–	–	–	–	–	–	–	–	–
8. *Indigofera hirsuta*	PP	PP	–	–	P	–	–	–	P	–	–	–
	PP	PP	–	–	P	–	–	–	–	–	–	–
	PP	–	–	–	–	–	–	–	–	–	–	–
	PP	–	–	–	–	–	–	–	–	–	–	–
9. *Aeschynomene indica*	P	P	–	–	P	–	–	–	P	–	–	–
	P	P	–	–	P	–	–	–	P	–	–	–
	P	P	–	–	–	–	–	–	–	–	–	–
	P	P	–	–	–	–	–	–	–	–	–	–
10. *Cassia tora*	P	–	–	–	P	–	–	–	–	–	–	–
	P	–	–	–	–	–	–	–	–	–	–	–
	P	–	–	–	–	–	–	–	–	–	–	–
	P	–	–	–	–	–	–	–	–	–	–	–
11. *Vicoa auriculata*	PP	PP	PP	PP	P	P	P	–	P	–	–	–
	PP	PP	PP	–	P	P	P	–	P	–	–	–
	PP	PP	PP	–	P	P	P	–	P	–	–	–
	PP	PP	PP	–	P	P	–	–	P	–	–	–
12. *Ammannia baccifera*	PP	PP	–	–	P	–	–	–	P	–	–	–
	PP	PP	–	–	–	–	–	–	P	–	–	–
	PP	PP	–	–	–	–	–	–	–	–	–	–
	PP	PP	–	–	–	–	–	–	–	–	–	–
13. *Phyllanthus simplex*	PP	PP	–	–	–	–	–	–	–	–	–	–
	PP	–	–	–	–	–	–	–	–	–	–	–
	PP	–	–	–	–	–	–	–	–	–	–	–
	PP	–	–	–	–	–	–	–	–	–	–	–
14. *Striga euphrasioides*	PPP	–	–	–	–	–	–	–	–	–	–	–
	PPP	–	–	–	–	–	–	–	–	–	–	–
	PPP	–	–	–	–	–	–	–	–	–	–	–
	PPP	–	–	–	–	–	–	–	–	–	–	–

PPP to a plot: Weed occurred in abundance
PP to a plot: Weed occurred in moderate frequency
P to a plot: Weed occurred occasionally

FIG. 2. Showing relative maximum population of weeds in number of plots out of total number examined (16) under the different N. treatments in the field having sugarcane crop during 1950.

only to the treatment effect, and may have some significance in the control of *Striga* in sugarcane. Timson (1938) as reported by Howard (1940) observed that addition of humus to soil in Rhodesia kept fields free from *Striga lutea.*

Ammannia baccifera while not exhibiting any appreciable differences in occurrence under fallow conditions, showed a distinct preference, under cropped conditions, to N-starved plots, occurring frequently in six to eight of the N_0 plots and only occasionally in one or two of the N_1 and N_2 plots. It appears late in September or in October when the sugarcane crop, having almost completed its grand period of growth, is on the way to maturity. Evidently it is unable to thrive under the dense canopy of the sugarcane crop in the N_1 and N_2 plots; the much poorer and open cane crop of N_0 treatment possibly offers greater facility for its establishment. *Jussieua suffruticosa,* seen in October and November in the fallow field, did not appear in the cropped field.

Desmodium triflorum throve well only in the N_0 plots where it occurred in almost all of the plots either abundantly or in moderate frequency, as against its occasional presence in the N_1 and N_2 plots, both under the cropped and fallow conditions. A similar tendency was exhibited by *Alysicarpus vaginalis* in both the fields. These plants seem to prefer soils where ammonium sulphate has not been applied. Their comparative infrequency in N_1 and N_2 plots under cropped conditions, seems to be due not to their inability to withstand the shade of the heavy cane crop, but to the treatmental differences themselves, since this preference was observed in fallow field as well.

Observations taken in September, 1951, in the cropped field with a view to check the occurrence of weeds confirm the findings of the previous year. *Desmodium triflorum* and *Alysicarpus vaginalis* occurred frequently in all and 13 plots, respectively, of the N_0 series as against their occasional occurrence in a plot or two in the N_2 series. *Aeschynomene indica, Indigofera hirsuta, Cassia tora, Vicoa auriculata* and *Striga euphrasioides* also exhibited a preference for the N_0 plots. *Physalis minima* and *Commelina benghalensis* throve better in the N_1 and N_2 plots where they were seen frequently, as against their occasional occurrence in N_0 plots.

Tables I and II bring out another interesting fact, that legumes in general e.g. *Desmodium triflorum, Alysicarpus vaginalis, Alysicarpus bupleurifolius, Rhynchosia minima, Indigofera hirsuta, Aeschynomene indica* and *Cassia tora* grow only in, or much more frequently in N_0 plots, suggesting that continuous addition of ammonium sulphate had set in conditions detrimental to the growth of all these weeds. This is particularly true of *Desmodium triflorum* and *Alysicarpus vaginalis.* Due to continuous application of ammonium sulphate, the soils of N_1 and N_2 plots were definitely acidic in reaction—their pH ranging between 6·2 to 6·8, while N_0 plots which recieved no nitrogen in the form of fertilisers had a pH value bordering on the alkaline side (Table III). The nitrogen content of soil from the ammonium sulphate treated plots was 0·022 to 0·007 per cent more than that of the control plots. One or both of these differences might underlie the differential occurrence of these weeds. Homes (1949) found that heavy nitrogenous manuring encouraged grasses, while reducing the occurrence of clovers and other dicotyledonous weeds. Suppression of clover by the application of N has

TABLE III

Showing average pH and soil nitrogen per cent in the different treatments

Treatments	Average pH of soil	Average nitrogen per cent
$N_0P_0K_0$ ...	7·1	0·048
$N_0P_2K_0$ ...	7·1	0·047
$N_0P_0K_2$ ...	7·1	0·046
$N_0P_2K_2$ ...	7·0	0·051
Mean ...	7·1	0·048
$N_1P_0K_0$ ...	6·8	0·053
$N_1P_2K_0$ ...	6·8	0·054
$N_1P_0K_2$ ...	6·8	0·046
$N_1P_2K_2$ ...	6·9	0·051
Mean ...	6·8	0·051
$N_2P_0K_0$ ...	6·2	0·051
$N_2P_2K_0$ ...	6·6	0·053
$N_2P_0K_2$ ...	6·3	0·048
$N_2P_2K_2$ ...	6·6	0·056
Mean ...	6·4	0·052

been observed in Sweden as well (1949). Experiments at Rothamsted, as quoted by Bharucha and Dubash (1951), have also shown that with the application of nitrogenous manure, grasses preponderated and expelled leguminous plants. Nielsen (1947) and Kelly (1947) found a pH above 7·0 to be most favourable for the growth of lucerne and clover.

Effect of continuous addition of P_2 O_5 and K_2 O on occurrence of weeds: No marked differences in the occurrence of weeds in response to continuous addition of P_2 O_5 and K_2 O could be observed both in the fallow and the cropped fields. This would mean either that the soils of the experimental fields are not deficient in K_2 O and P_2 O_5, or that the occurring weeds have no preference for or against these nutrients. Normally one may expect some difference in the occurrence of legumes in response to these treatments but the data presented in Table IV and V show no such difference.

TABLE IV

Showing number of plots out of total number observed (24) in which the leguminous weeds occurred in K_0, K_2 and P_0, P_2 series under fallow conditions.

Name of weeds	K_0 Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	K_2 Mar	April	May	June	July	Aug.	Sep.	Oct.	Nov.
1. *Desmodium triflorium*, DC. ...	5	10	12	14	11	16	Observations not recorded	12	11	7	10	12	14	11	10	Observations not recorded	14	12
2. *Alysicarpus vaginalis*, DC. ...	...	...	...	...	2	3		4	3	...	...	...	...	1	4		4	3
3. *Aeschynomene indica*, Linn. ...	...	...	...	...	...	2		1	...	...	...	...	...	...	2		2	...
	P_0									P_2								
1. *Desmodium triflorum*, D.C. ...	7	11	13	14	12	13		14	10	5	9	11	14	10	13		12	13
2. *Alysicarpus vaginalis*, DC. ...	...	...	...	...	2	4		4	3	...	...	...	...	1	3		4	3
3. *Aeschynomene indica*, Linn. ...	...	...	...	...	...	2		1	...	...	...	...	...	...	2		2	...

TABLE V

Showing number of plots out of total number observed (24) in which the leguminous weeds occurred in K_0, K_2 and P_0, P_2 series under cropped conditions

Name of weeds	K								P							
	K_0				K_2				P_0				P_2			
	Aug.	Sep.	Oct.	Nov.	Aug.	Sep.	Oct.	Nov.	Aug.	Sep.	Oct.	Nov.	Aug.	Sep.	Oct.	Nov.
1. *Desmodium triflorum* DC. ...	10	9	8	8	11	11	11	12	9	12	10	11	12	8	9	9
2. *Alysicarpus vaginalis*, DC.	9	10	9	11	13	10	8	10	10	9	9	11	12	11	8	10
3. *Aeschynomene indica*, Linn. ...	3	6	3	2	...	5	1	1	...	4	1	1	3	7	3	2
4. *Cassica tora*, Linn.	...	4	3	1	...	1	...	1	...	2	1	1	...	3	2	1
4. *Indigofera hirsuta*, Linn. ...	4	4	4	4	5	5	4	3	6	6	5	5	3	3	3	2
6. *Bhynchosia minima*, DC. ...	3	2	2	3	3	1	4	3	3	1	3	3	3	2	3	3

Other weeds and their seasonal succession: Under fallow conditions, other weeds (Appendix I) showed no appreciable differences in occurrence as between the treatments. In the pre-monsoon period *Eclipta alba*,

Vernonia cinerea, *Erigeron canadensis*, *Blumea wightiana*, *Launaea nudicaulis*, *Euphorbis hirta*, *Laggera aurita*, *Convolvulus arvensis* and *Vicoa vestita* occurred more or less frequently in all the plots, irrespective of the treatment differences. With the beginning of rains, i.e. July onwards, other species viz., *Aneilema nudiflorum*, *Lindernia ciliata*, *Vandellia crustacea*, *Ipomaea pestigridis*, *Phyllanthus niruri*, *Corchorus acutangulus* and *Melochia corchorifolia* were frequently seen in all the treatments. Some of the pre-monsoon weeds like *Blumea wightiana* and *Laggera aurita* dried out in this period, having completed their life cycle. In October and November, *Oldenlandia corymbosa* was frequently met with, while *Trichodesma indicum. Volutarella divaricata*, *Digera arvensis* and *Leucas aspera* were less common. In the pre-monsoon and rainy seasons *Trichodesma indicum*, *Pulicaria crispa*, *Tridax procumbens*, *Oxalis repens*, *Portulaca oleracea*, *Boerhaavia repens*, *Carthamus oxyacantha*, *Heliotropium strigosum*, *Cichorium intybus*, *Alternanthera sessilis* and *Cucumis* sp. also occasionally grew in stray plots here and there.

Under cropped conditions as well, during the rainy season, *Aneilema nudiflorum*, *Lindernia ciliata*, *Vandellia crustacea*, *Corchorus acutangulus*, *Euphorbia hirta*, *Eclipta alba*, *Phyllanthus niruri*, *niruri*, *Ipomaea hispida*, *Ipomaea pestigridis*, *Convolvulus arvensis* and *Melochia corchorifolia* occurred frequently in most of the plots irrespective of the treatment differences. In October and November, *Vernonia cinerea*, *Oldenlandia corymbosa*, *Melochia corchorifolia*, *Euphorbia hirta*, *Corchorus acutangulus* and *Eclipta alba* were frequently seen in most of the plots. *Cucumis* sp. *Portulaca oleracea and Digera arvensis* during August and September and *Achyranthes aspera*, *Evolvulus nummularius*, *Tridax procumbens and Leucas aspera* during October and November were also met with in stray plots.

Nature of competition between weeds and sugarcane crop: The average numbers of weed species occurring in N_0, N_1 and N_2 series in successive months are shown under cropped and fallow conditions in Table VI.

TABLE VI

Showing the average number of weed species found in plots of N_0, N_1 and N_2 series

Month	Under cropped condition				Under fallow condition			
	N_0	N_1	N_2	S.E.	N_0	N_1	N_2	S.E.
March ...	Weed occurrence affected by frequent cultivation				3·3	3·4	3·8	
April ...	operations etc., till July.				5·9	6·8	7·4	
May ...					6·9	7·8	8·6	
June ...					7·3	8·3	7·6	
July ...					6·5	6·9	5·7	
August ...	14·8	12·9	12·2	±0·48	14·3	13.9	13·4	±1·15
September ...	16·7	11·8	11·7	±0·89	Observations not recorded			
October ...	17·0	12·3	11·3	±0·83	12·0	14·1	13·1	±0·61
November ...	15·1	10·8	8·9	±1·03	10·4	11·5	10·8	±0·41

It is interesting to note that in the field lying fallow the number of species occurring per plot did not on the average vary significantly as between the three N-treatments. In the cropped field, however, this difference was statistically significant, the average number of species occurring in N_0 plots exceeding those in N_1 and N_2 by about five or six. The reduction in the number of species in the N_1 and N_2 plots is obviously the result of the greater shading by the crop receiving fertiliser. This becomes more clear when subsequent monthly observations on the average number of weed species occurring in plots of the N_0, N_1 and N_2 series are compared separately. There is slight increase in average number of weed species occurring per plot in N_0 series in the cropped field during September and October as compared to August. In N_2 series on the other hand, this number went on dwindling as the crop grew taller and more dense and the average number of weed species per plot came down from 12·2 in August to 8·9 in November. August onwards only such of the weeds as could tolerate shade came up or persisted in the N_1 and N_2 plots (Table VII).

Because of their twining habit, *Convolvulus arvensis* and *Ipomaea pestigridis* could avoid shade and persisted in the N_1 and N_2 plots in the cropped field.

TABLE VII

*Showing species of weeds which could tolerate or evade shade and occurred equally frequently in the three nitrogen treatments under cropped conditions**

Treatments	N_0				N_1				N_2			
Time of observation	Aug.	Sep.	Oct.	Nov.	Aug.	Sep.	Oct.	Nov.	Aug.	Sep.	Oct.	Nov.
1. *Vandellia crustacea*, Benth.	15	16	6	3	16	15	2	2	16	14	3	...
2. *Lindernia ciliata*, (Collsmann) Pennel.	16	16	3	3	16	15	...	...	16	10	...	...
3. *Aneilema nudiflorum*, R. Br.	15	15	9	1	16	16	7	1	16	15	14	3
4. *Corchorus acutangulus*, Lamk. ...	16	16	16	16	16	16	16	16	16	16	16	15
5. *Euphorbia hirta*, Linn.	14	16	15	15	13	8	13	10	14	13	11	14
6. *Phyllanthus niruri*, Linn.	15	15	10	7	16	13	12	7	16	15	12	5
7. *Eclipta alba*, Hassk.	11	11	11	11	10	6	11	12	12	11	13	11
8. *Melochia corchorifolia*, Linn. ...	7	8	10	9	8	8	8	7	7	8	8	8
9. *Vernonia cinerea*, Less.	...	1	9	9	...	1	8	8	...	...	8	8
10. *Oldenlandia corymbosa*, Linn. ...	...	6	14	13	...	3	11	13	...	2	12	9
11. *Convolvulus arvensis*, Linn.	11	12	12	12	8	9	8	8	9	11	12	12
12. *Ipomaea pestigridis*, Linn.	13	14	14	14	16	14	14	12	11	9	8	8

*Figures denote number of plots out of total number examined (16) in which the weeds occurred.

SUMMARY

Observations were made at Shahjahanpur, U.P. to see whether continuous application of ammonium sulphate (N), superphosphate (P) and potassium sulphate (K) singly or in different combinations to the same plot over a number of years has any direct or indirect effect on the occurrence of weeds associated with the sugarcane crop.

It was observed that leguminous weeds occurred with much greater frequency in N_0 plots which had not been fertilised with nitrogen and were very few in plots which had regularly received doses of ammonium sulphate (N_1 and N_2). *Desmodium triflorium* and *Alysicarpus vaginalis* were particularly selective in this respect. The soil of N_0 plots had an average nitrogen content of 0·048 per cent and average pH of 7·1, while the N_1 and N_2 plots showed 0·051 per cent and 0·052 per cent nitrogen and 6·8 and 6·4 average pH respectively.

Striga euphrasioides was observed occurring in one replication in both the fields and only in the N_0 plots of it. In these plots it was found occurring in abundance, whereas in the N_1 and N_2 plots of the same replication it was conspicuous by its complete absence.

Chenopodium album, *Commelina benghalensis*, *Polygonum plebejum* and *Physalis minima* throve well in the nitrogen-fed plots. The first two of these in particular did not usually grow in the plots receiving no ammonium sulphate and even when they came up in these, they remained stunted.

No marked differences in the occurrence of weeds could be observed as between the K_0 and K_2 and P_0 and P_2 treatments.

In the field having sugarcane crop the number of weed species occurring was significantly more in the N_0 plots as compared to N_1 and N_2 plots. This difference became more pronounced during the months of September, October and November. In the fallow field, however, no appreciable difference in the number of weed species was observed as between the different nitrogen-treatments. From August onwards, only the shade-tolerant or shade-evading plants persisted in the N_1 and N_2 plots under cropped conditions.

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APPENDIX I

List of weeds occurring under *different ecological conditions.*

A. Weeds occurring in plots where no nitrogenous fertiliser has been added to soil. (pH 7·0—7·1, nitrogen status low).

1. *Desmodium triflorum*, DC.
2. *Alysicarpus vaginalis*, DC.
3. *Alysicarpus bupleurifolius*, DC.
4. *Rhynchosia minima*, DC.
5. *Indigofera hirsuta*, Linn.
6. *Aeschynomene indica*, Linn.
7. *Cassia tora*, Linn.
8. *Vicoa auriculata*, Cass.
9. *Phyllanthus simplex*, Retz.
10. *Striga euphrasioides*, Benth.

B. Weeds occurring in plots receiving Ammonium sulphate (pH 6·2—6·8, nitrogen status high).

1. *Chenopodium album*, Linn.
2. *Polygonum plebejum*, R.Br.
3. *Physalis minima*, Linn.
4. *Commelina benghalensis*, Linn.

C. Weeds which could tolerate shade of cane crop.

1. *Vandellia crustacea*, Benth.
2. *Lindernia ciliata*, (Colsmann) Pennell.
3. *Aneilema nudiflorum*, R. Br.
4. *Corchorus acutangulus*, Lamk.
5. *Euphorbia hirta*, Linn.
6. *Phyllanthus niruri*, Linn.
7. *Eclipta alba*, Hassk.
8. *Melochia corchorifolia*, Linn.
9. *Vernonia cinerea*, Less.
10. *Oldenlandia corymbosa*, Linn.

D. Other weeds occurring at random and showing no differential preference in respect of occurrence.

1. *Erigeron canadensis*, Linn.
2. *Blumea wightiana*, DC.
3. *Argemone mexicana*, Linn.
4. *Launaea nudicaulis*, Hook.
5. *Laggera aurita*, Schultz-Bip.
6. *Convolvulus arvensis*, Linn.
7. *Tridax procumbens*, Linn.
8. *Vicoa vestita*, Benth.
9. *Salvia plebeia*, R. Br.
10. *Trichodesma indicum*, R. Br.
11. *Pulicaria crispa*, Schultz-Bip.
12. *Oxalis repens*, Thumb.
13. *Portulaca oleracea*, Linn.
14. *Boerhaavia repens*, Linn.
15. *Carthamus oxyacantha*, Bich.
16. *Heliotropium strigosum*, Willd.
17. *Cichorium intybus*, Linn.
18. *Alternanthera sessilis*, R. Br.
19. *Ipomaea pestigridis*, Linn.
20. *Ipomaea hispida*, R. & S.
21. *Digera arvensis*, Forsk.
22. *Volutarella divaricata*, Benth. & Hook.
23. *Solanum nigrum.*, Linn.

24. *Cucumis* sp.
25. *Leucas aspera*, Spreng.
26. *Convolvulus pluricaulis*, Chois.
27. *Celosia argentia*, Linn.
28. *Achyranthes aspera*, Linn.
29. *Evolvulus nummularius*, Linn.
30. *Anisomeles ovata*, R. Br.
31. *Ammania baccifera*, Linn.
32. *Jussieua suffruticosa*, Linn.

NOTES ON FOREIGN CANE VARIETIES

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BEFORE the discovery of viable seeds in sugarcane, exchange of varieties between countries for commercial propagation was an important feature of the world's sugar industry. Varieties were sometimes acquired by some colonial sugar interests at great cost and propagated in their plantations. The eastern countries particularly the Indonesian, Melanesian and Polynesian islands where tropical sugarcane is believed to have originated, were the principal sources of varieties.

Because of the early adoption of sugarcane cultivation in India, this country has always been fairly rich in sugarcane material. The Indian sugar industry of the last century was based largely on indigenous canes, which are in many respects distinct from tropical sugarcanes. In the last quarter of the 19th century, efforts were made by some of the British sugar concerns in India to introduce certain varieties of sugarcane from abroad. The varieties were imported and propagated in commercial cultivation with a confidence born out of their success in other countries. Unfortunately, these varieties proved unsuccessful and as a result, cane production in those areas received a serious set-back (Noel Deerr, 1949). The venture showed that introducing varieties from one country to another could be very risky and brought a change of policy and outlook in regard to sugarcane improvement. It was felt thereafter that improvements under Indian conditions could be made only on a foundation of indigenous material (Watt, 1893). Thus the ensuing decade saw a revival of interest in indigenous canes.

The first collection of indigenous varieties was started in the early years of the present century by Hadi (1902) in U.P. At Sabour in Bihar, Woodhouse and Basu (1915) assembled a number of varieties. Barber at Coimbatore started a collection which included indigenous varieties from all parts of India and also several officinarum canes which were being grown for chewing or for manufacture of *gur* or sugar in many parts of India. The primary objective of these collections was a comparative study of the varieties and selection from among them for purposes of cultivation.

Barber's studies on varieties (1916) were continued over a number of years. He found, however, that although the varieties were many, the potentiality of the material, within any one species was somewhat restricted and much improvement was not possible. Very soon, therefore, attempts were made at Coimbatore to breed new varieties and raise seedlings by hybridization, using the indigenous varieties and officinarums. The success that attended these efforts was moderate, but it paved the way for a more ambitious venture, viz. inter-specific crosses between sugarcane and *Saccharum spontaneum*, from which with many additions, breedings-in and breedings-out, the long series of Co. canes ultimately arose.

With the adoption of sugarcane breeding-work in various cane-growing countries, varietal exchange between countries took on a new complexion; varieties were now sought out and imported as possible breeding material or germ plasm.

At Coimbatore many foreign varieties were thus imported and pressed into service as parents: among these were B. 3412, B. 6308 from Barbados, CAC. 87 from Philippines, D. 74 from British Guiana, C.P. 807 from U.S.A., Purple Mauritius, Red Mauritius from Mauritius, Black Cheribon, S.W. III, E.K. 28, POJ. 100, POJ. 213, POJ. 2725 and POJ. 2878 from Java and H. 109 from Hawaii. Some of these, e.g. E.K. 28, POJ. 2878, Badila, Red Mauritius, etc. were fairly successful in peninsular India and were in cultivation in certain parts till they were replaced by Co. 419 and other Co. canes. In the northern provinces, the primary derivatives of the original crosses between *Saccharum spontaneum*, *Saccharum officinarum* and *Saccharum Barberi*, evolved in the early years of breeding work, did well and found wide acceptance among growers. Out of genetic net-work woven out of this material, an enormous variation in progeny was obtained, and the seedlings showed a capacity for adaptation to adverse climatic and agricultural conditions such as had never been seen before. The demand for high yielding, rich and disease-resistant canes was adequately met through selection from these progenies. Meanwhile the work of importation of varieties continued at

Coimbatore. Some of the acquired material provided " new blood ", and in the programme of breeding over the next 25 years, a wide range of parents was tested out and crosses were made in as many combinations as the flowering of the desired parents permitted.

But while the main objective was being fulfilled by the skilful use of the acquired material in breeding, the possibility of adopting the imported canes directly into commercial cultivation was not overlooked. Several varieties from Java and U.S.A. were sent out to State Research Stations for testing, during the early years of the establishment of the sugar industry, that is between 1932 and 1938. These varieties apparently failed to come high enough in their performance and were rejected even in the early stages of selection. Soon after, the war intervened, and the exchange of varieties between the sugarcane growing countries of the world came to a standstill. With the occupation of Java by the Japanese, contacts with the Java Sugar Industry Research Station were completely broken off, and the varietal collection there was, to all intents and purposes, lost. In many countries, the breeding work itself was severely curtailed. Fortunately, in India breeding and selection work went on almost unhindered, and varietal progress was kept up with the germ plasm acquired and synthesised during the earlier years.

Since 1945, the varietal exchange between interested countries has been resumed; during the 10 years 1945 to 1955 the Coimbatore Station imported as many as 400 varieties. In 1955-56 the collection at Coimbatore was raised to the status of a World Collection, and following upon its recognition as such by the International Society of Sugarcane Technologists, steps were taken to expand it and bring it into line with the collection maintained by the U.S. Government at Canal Point, Florida (Dutt, 1956). With the generous financial assistance of the Technical Co-operation Mission of the U.S. Government, over 900 varieties of cane have now been imported from the U.S.A., and added to the Coimbatore Collection. This acquisition includes noble canes (*S. officinarum*), robustums (*S. robustum*), edules (*S. edule*), spontaneums (*S. spontaneum*) and 180 hybrid commercial canes from about a dozen countries, including Barbados, Brazil, China, Colombia, Cuba, Puerto Rico, South Africa, Taiwan and the U.S.A. There are now about 2,000 canes in the World Collection, apart from about 600 wild cane varieties.

The importation of sugarcane varieties from foreign countries is beset with some difficulties and dangers, and has to be done with circumspection. Under our Plant Importation rules, because of the occurrence of certain serious diseases in some foreign countries, the importation of varieties from those countries is prohibited. If a variety from Queensland or Philippines, for instance, is needed, it has first to be imported into a country which is free from the Fiji disease of sugarcane and quarantined there for 2 or 3 years, this being the incubation period of the disease. It is only after this that it can be imported into India, provided of course the variety, meanwhile, does not develop the symptoms of the disease.

Again, not all artificially-bred foreign varieties can be commercially grown outside the countries of their origin. In the case of some varieties, there is a temporary restriction. They cannot be grown by other countries or sugar industries till a fixed number of years have elapsed after the initial release of the variety. Some varieties are patented and their propagation is governed by the proprietary rights of the concerned breeder or breeding organisation. Before the variety can be grown commercially by sugarcane industries elsewhere, special agreements have to be entered into with the concerned breeding organisations, and royalties are charged.

Actually, however, more than these, our cultural conditions circumscribe the number of varieties that can be adapted and grown in this country. Our major cane area is in the sub-tropics, and there cane is grown under severe climatic stresses, and at present with only the barest minimum essentials of culture. These conditions are rather unusual for sugarcane, and varieties of the tropical " noble " standard cannot be expected to be successful under them. The varieties have also to be resistant to the particular diseases and strains of disease-organisms which are prevalent in India, and have to be tested against them before they can be selected for cultivation.

With all this, some of the foreign varieties may succeed under our conditions. During the last few years, the standard of cultivation has improved considerably in many of our tracts, and cane now receives more adequate irrigation and fertilizer application than it did before. In some of the peninsular areas, the standard has always been fairly high, and now if anything, further improvement has taken place. An other factor is that with the extension of sugarcane cultivation, the trend in breeding has been towards hardier varieties with a wide range of disease-resistance. Most of the commercial varieties of the world today are descended from the bi- or tri-specific hybrids originally produced in Java and India. Some of the modern foreign varieties may therefore be successful under Indian conditions; it is purely a matter of trial and careful choice of material.

In these notes, it is proposed to give brief back-ground information about important foreign varieties, viz. their characteristics and agricultural qualities (*) and the cultural conditions obtaining in the countries where they are being commercially cultivated, together with some details about the breeding centres where they were evolved. This first note deals with the United States of America.

I. The United States of America

The entire sugarcane area in the U.S.A. is in the sub-tropics, largely in Florida and Louisiana, and to a lesser extent in other Southern States. Florida is roughly 25° to 30° N and Louisiana is 30° to 33° N, and in this respect they correspond respectively to Uttar Pradesh and East Punjab in India. There are some similarities, as also some differences between the two. Florida, unlike Uttar Pradesh, is a low-lying peninsula with very fertile accumulations of dark muck and peat soil, rich in organic matter. Jutting out in the Gulf of Mexico, it has a fairly equable climate. Louisiana, on the other hand, is liable to severe winter-frosts. A large part of it is the deltaic flood-basin of the Mississipi river, and is unlike East Punjab, poorly-drained. Cane is grown in reclaimed marshlands which are rich in organic matter deposited under conditions of excessive moisture. Both Florida and Louisiana are subject to tornadoes. The soil is naturally fertile and favours luxuriant cane growth—in contrast with many of our cane areas whose soils are extremely deficient in organic matter.

The centres in Florida where sugarcane breeding is carried on are (1) Canal Point (2) Everglades and (3) Clewiston. In Louisiana varietal work in sugarcane is done by the State University. In addition, the United States Department of Agriculture has its field station at Houma in Louisiana, established since 1932, where large-scale progeny-testing is carried on.

(1) **Canal Point:** Sugarcane breeding in the United States began at Canal Point, Florida, in 1919. The early breeding work was directed towards evolving varieties resistant to mosaic, which between 1916 and 1926, had caused a near-collapse of the Louisiana sugar industry. The two *S. officinarum* varieties then in cultivation, viz. Louisiana Purple and D 74 were totally devastated by this virus disease. Some relief was obtained by replacing these varieties with the mosaic-tolerant POJ. varieties from Java, but with Co. 281, the industry is reported to have made a sensational recovery. In the breeding work which followed, Co. 281 was, therefore, repeatedly used and some of its derivatives evolved at Canal Point followed it in commercial cultivation (Brandes, 1936; Coons, 1953). The problem of disease-susceptibility having been overcome, the breeding objectives and seedling selection criteria were enlarged to include early maturity with relatively high level of sucrose content, resistance to freeze-injury in both cut cane and ratoons, erect growth habit, resistance to borers and freedom from red-rot and root-rot. The most important among the C.P. varieties are referred below:

(i) *C.P. 29/320* (Co. 281×C.P. 27/34). One of the outstanding offsprings of Co. 281 and for a long time the dominant variety in the northern section of Louisiana sugar belt. Its most important feature is its adaptability for machine-harvesting because of its erect habit. Sartoris (1947) has recorded that this variety served as the 'guinea pig' for the development of the mechanised cane agriculture in the United States. It is said to be susceptible to smut (Cross, 1945).

At Coimbatore C.P. 29/320 has given a good performance. It is a medium cane with a characteristic erect habit, good tillering and early cane-formation. Stalks are uniform with long internodes. A mid-season maturing type; at 12 months, it has given 17 per cent sucrose and 85 per cent purity—the highest among all the C.P. varieties tested during the current season. Its fibre content is also comparatively low (14 per cent). The variety has been utilized at Coimbatore as a parent in breeding in combinations with Co. 453 and Co. 617.

(ii) *C.P. 33/224* (C.P. 27/139 × C.P. 31/432) was a promising variety in the early years of its release, but did not gain much acreage. It has been largely employed as a proven parent because of its erect habit (Abbott and Summers, 1950).

The variety has done well at Coimbatore. It is a vigorous cane of Co. 312 type and is capable of heavy yields. It has a satisfactory sucrose content (16 per cent) and might do well as a late cane. Its fibre value is lowest (12 per cent) among the C.P. canes. It tends to lodge because of top-heaviness.

(iii) *C.P. 34/79* [(POJ. 2878 × Badila)×C.P. 1161]. Released for commercial planting in 1945. Best adapted for sand and muck soils. An early to mid-season cane giving good yield. Stalks are erect and self-trashing, characters advantageous for machine-harvesting. Said to be resistant to red rot, leaf spot and

(*) The notes given on varieties in this paper refer only to their record in the countries of their origin and observations made on one or two rows at Coimbatore. Their performance in the different cane tracts in India can be assessed only after the varieties have been fully tested in the respective State Research Stations.

mosaic and to pests like the stem borer. It is reputed as a good ratooner. The disadvantages are its high fibre content and susceptibility to chlorotic streak (Sartoris *loc. cit.* Anon, 1945).

The performance of this variety under Coimbatore conditions has been encouraging, with its erect habit, good tillering and freedom from mosaic. It tends to be an early cane here, recording 16 per cent sucrose at 10 months' age, and its fibre is not high (14 per cent). This variety has also been included as a parent in breeding.

(iv) *C.P. 36/105* (Co. 281 × C.P. 1165) released in 1945. Equalling Co. 281 in sugar yield, but not in its superior windrowing quality, the variety is said to suit a wide range of environmental conditions. It yields well and does not deteriorate rapidly. It is said to possess good stubbling properties, i.e. its ratoons show resistance to stubble failure resulting from frost. It is reported resistant to red rot and root rot, but is slightly susceptible to other diseases (Brandes *et. al.* 1945; Abbott, 1953).

The variety has proved an early tillerer, good yielder with satisfactory field habit, under our conditions. It can be useful as a high-yielding late cane with moderate sugar content (13 per cent). The canes have a heavy bloom and in old canes there is a tendency for the formation of "lalas" (side shoots).

(v) *C.P. 44/101* (Co. 281 × C.P. 1165). This cane has proved the most outstanding among the later C.P. releases and has out-yielded all other varieties in sugar per acre (Hebert *et. al.* 1951). It is now the premier cane with a steadily increasing acreage; it occupied 42 per cent of the area in 1955 (Hebert, 1955) doing well both on light and heavy soils. It is also reputed to be disease-resistant (Stevenson and Jones, 1953).

The variety has fared well at Coimbatore as a heavy yielder with an early tillering habit. The canes are erect with long internodes. It is a mid-season maturing type. In recent years it has become very susceptible to mosaic and with great care a limited amount of disease-free material in this variety is being maintained in the World Collection.

(vi) *C.P. 49/50* (Parentage not available). One of the promising new productions. It has proved superior to C.P. 36/105 but not to C.P. 44/101 in regard to cane yield.

At Coimbatore it is a vigorous, heavy-yielding Co. 453-type of cane. Canes are medium thick and erect while young, but heavy crops are likely to lodge. At 12 months, it has recorded 15 per cent sucrose which might improve and the variety can perhaps be harvested as a late cane. It has remained free from mosaic infection ever since 1950 when it was received here.

Among other C.P. varieties mention may also be made of C.P. 36/111 which proved useful for syrup production (Stokes *et. al.* 1952) and the new varieties—C.P. 44/33, C.P. 44/92, C.P. 44/155, C.P. 44/184, C.P. 48/103, C.P. 50/11 and C.P. 50/28 which are said to be promising; but none of these have so far reached commercial importance (Hebert *et. al.*, *loc. cit.* Gonaux and Stafford, 1955). All these new varieties have recently been imported from U.S.A. and are under multiplication at Coimbatore.

2. Everglades Experiment Station: This was started later than Canal Point. Its breeding objectives are fitness for peat soils, early ripening to escape frost-damage, and disease resistance. The selections are given F. numbers, the letter standing for Florida Agricultural Experiment Station. The commercial cultivation of many of these varieties is governed by patent rights (Bourne, 1939). The first variety to be released from the Florida Experiment Station was F. 30-35. The important varieties issued are:

(i) *F. 31-436* (C.P. 2735 × POJ. 2725) carries the U.S. plant patent No. 220 of 1937 in the name of its breeder Benj. A. Bourne. The variety is reputed to possess resistance to cold damage, high sugar content, early maturity and resistance to leaf diseases like mosaic and those due to *Helminthosporium* sp. (Bourne, 1940).

The variety has recorded a steadily decreasing vigour during the last 8 years it has been maintained at Coimbatore. It has very broad leaves, stunted canes with short cylindrical nodes and low fibre. It thus very much resembles the *S. officinarum* varieties. It is drawn upon as a parent for breeding at Coimbatore.

(ii) *F. 31-962* (Co. 281 × C.P. 27/108). This is also one of Dr. Bourne's patent canes (U.S. patent No. 203 of 1936) and is an important commercial variety in Florida. Besides desirable stalk characters, it has rich juice and early maturing quality and this facilitates the early commencement of the factories. In 1940, the variety was occupying the largest acreage in Everglades area of Florida (Bourne, 1940).

At Coimbatore F. 31-962 has proved a better cane than F. 31-436 in regard to vigour and general stand. The canes are erect and uniform, but are stunted with short internodes. It is an early maturing type with rich juice (17 per cent sucrose at 12 months), but seems to be capable of only low yields. It is susceptible to mosaic. The variety has been used in breeding because of its early maturity.

F. 36-779 and F. 36-819 are other varieties which are reported to do well (Abbott and Summers, *loc. cit.*). These varieties have been received only recently at Coimbatore. So far as is known, none of the F. varieties have proved serious competitors to C.P. canes.

3. Clewiston (Florida) is the name of the place where the cane-breeding station of the U.S. Sugar Corporation is located. It is the home of Cl. varieties. The breeding work is of recent origin. The main objective of this station is to produce varieties resistant to diseases especially mosaic. Some of the Cl. varieties are patented (H.M.L. 1951). Cl. 41-70 (C.P. 29/103 × Co. 301) and Cl. 42-75 (F. 31-962 × F. 31-436) are said to be immune to mosaic, whereas Cl. 38-32 (Co. 281 × C.P. 27/108) and Cl. 41-67 (C.P. 29/103 × Co. 301) are reported as highly resistant to it. These varieties have recently been imported at Coimbatore and it will be some time before any information can be had regarding their usefulness.

Among the varieties described above, five C.P. canes viz.: C.P. 29/320, C.P. 33/224, C.P. 34/79, C.P. 36/105 and C.P. 49/50 have been sent for trial to the various sugarcane stations in India. Reports of their performance there are awaited. The other varieties sent are Pindar, Q. 49, Q. 50, N.Co. 291, N.Co. 351 and Tuc. 521.

Summary

Import and exchange of varieties was an important activity of the sugar industries of the world before breeding was started. In India the sugar industry had an early origin and a large number of indigenous varieties were in commercial cultivation. Early attempts made by certain British sugar concerns in India to import the thick type *S. officinarum* varieties gave the industry a serious set-back, and research was thereafter directed to indigenous material.

At the Coimbatore Institute, the first work done was to assemble all the indigenous and such exotic varieties as were available. Initial hybridization work involved the use of these foreign and Indian canes, but striking success was achieved only after making use of the wild species *Saccharum spontaneum* in breeding. In the subsequent expansion of the breeding work a large number of varieties e.g. POJ. 2878, B. 3412, CAC. 87, C.P. 807, D. 74, and Tuc. 521, Q. 49, Q. 50, Pindar etc. were imported and pressed into service as parents. The varietal collection thus built up at this Institute has now been raised to the status of a World Collection.

During the early years, some hybrid canes from Java and U.S.A. were tried at state research stations for possible use as commercial canes. But their performance was not encouraging. Imports of foreign varieties and their trial as commercial canes were held up by World War II. It has now been resumed.

The commercial cultivation of some foreign varieties is restricted by proprietary rights of the concerned breeding organizations. Diseases prevalent in this country and our climatic and cultural conditions further circumscribe the number and range of foreign varieties for use in India. However, some varieties may prove successful.

Brief details about the objectives of the breeding stations, and cultural conditions in Florida and Louisiana are presented. Characteristics of some important varieties from U.S.A. viz. C.P. 29/320, C.P. 33/224, C.P. 34/79, C.P. 36/105, C.P. 49/50, C.P. 44/101, C.P. 49/50, F. 31/436, F. 31-962, Cl. 41-70 and Cl. 42-75 are given, together with notes on their performance at Coimbatore. Of these the first five have been sent to State Research Stations for testing together with Pindar, Q. 49, Q. 50, N.Co. 291, N.Co. 351 and Tuc. 521.

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THIRD ALL-INDIA CONFERENCE OF SUGARCANE RESEARCH AND DEVELOPMENT WORKERS IN THE INDIAN UNION

The Third All-India Conference of Sugarcane Research and Development Workers was held at Pusa, Bihar, from October 25 to 31, 1957. The Conference, which was inaugurated by the Chief Minister of Bihar, was attended by about 400 delegates from all over the country. The work of the Conference was carried out through six sections, namely, agronomy and physiology, breeding and botany, chemistry and soil science, entomology, pathology and development. The Conference considered 119 papers received from research and development workers. In addition, there were special symposiums on red rot and varietal deterioration. —*Editor*

PRESIDENTIAL ADDRESS

By

T. C. Puri, I.C.S.

(General President and Joint Secretary to the Government of India, Ministry of Food and Agriculture)

I CONSIDER it a special privilege to present this Address to this distinguished gathering of research and scientific workers and others interested in the sugar and sugarcane industries, which constitute the second largest industry in the country and also occupy an unrivalled position in the agricultural economy of our motherland. I am thankful to the Bihar Government for inviting the Conference to hold their third session at their premier sugarcane station, the Sugarcane Research Institute, Pusa. From the point of view of sugar industry the position of Bihar with its 30 sugar factories and over four lakh acres under sugarcane is second only to Uttar Pradesh, and together, the two States share almost 60 per cent of the total production of white sugar and almost 70 per cent of the acreage under sugarcane in India. It would be appropriate before I proceed further, that I should convey to Dr. Sinha and Shri Patel, the gratitude of the Indian Central Sugarcane Committee and the workers at the sugarcane research stations and sugarcane development centres attached to the various schemes financed and subsidised by the Committee. This occasion is particularly appropriate since it coincides with the 71st birthday of you, Sir, our Chief Patron. We all wish you long, long years of happy and meritorious service to our motherland. Sir, you have very kindly agreed to inaugurate the third session of the Conference today and also to preside over the plenary session on the 31st. Knowing your onerous duties and numerous engagements which heavily tell upon your time, we all feel immense pleasure and are greatly inspired to see your keen interest in the Conference and the welfare of the industry by sparing so much of your valuable time for the Conference. Under your inspiration, Sir, the State Government and its officers from the Secretary, Agriculture and Development Department to the workers at the research station have all contributed their mite to organise the meetings and the functions connected with this Conference for which our grateful thanks are due to all of them.

This is the third conference of sugarcane research and development workers and I hope the scientists, who have collected here, will avail themselves fully of the opportunity provided to them to exchange ideas on various scientific problems connected with the industry in our country. At these conferences by mutual discussions, formal or informal, between colleagues working in different States, it is always possible to strike fresh avenues of thought and new lines of action. As we move forward through years, we feel the cumulative effect of both the amounts of money spent for sugarcane research and development as well as the quantum of data collected. It becomes most essential that we should review the work done, information utilised, achievements made and the procedures followed with a view to cut across the rank growth of routine activity which always has a strong tendency to suppress whatever originality of thought points out as a new line of action. All manner of work of a routine type, particularly in the research field, should be subjected to frequent scrutiny. The first session of the Conference was held at Coimbatore in 1951 and the second was held at Jullundur in 1954. The deliberations of the delegates at these sessions were received with applause by the industry and I shall look forward to more frequent sessions of the Conference as already decided by the Indian Central Sugarcane Committee.

Progress of the Industry

It would be useful to note that in 1920 the first comprehensive report was submitted by the Sugar Committee of the Indian Council of Agricultural Research and the foundations of the Industry were laid, though the work on the super-structure did not begin in right earnest till 1930-31 when fiscal protection was

granted by way of a protective duty. During the last almost three decades the Industry has progressed, developed and raised the country from an importer of sugar to that of an exporter of white sugar to important parts of the world. So far nearly 1·7 lakh tons of white sugar have been exported and plans are now afoot to export at least two lakh tons annually. Sugar would, thus, become a commodity which could bring every year valuable foreign exchange to the tune of 17 to 18 crores of rupees after local needs have been satisfied. The fiscal protection introduced by the Government of India, to control imports of sugar in the country, stimulated the growth of the milling industry and the number of sugar factories rose from 32 in 1930-31 to 166 to 1956-57. The milling industry alone now provides livelihood to 1·4 lakh persons besides the block capital of over 70 crores invested in it. Looking at its achievements from the Plan targets point of view, the Second Five-Year Plan target of 2·25 million tons of white sugar will be fully achieved since in 1956-57 the production was already over 2·02 million tons. The technological researches for the Industry are looked after by the Development Council for the Sugar Industry. On the agricultural side i.e. cultivation and marketing of sugarcane, the livelihood of 20 million people is linked with sugarcane, which is now planted over 40 lakh acres distributed practically in all the States.

Progress in Research

Sugarcane cultivation, in a way, is unique in that it is grown in the Punjab with its frost-bitten winter climate and in the flooded areas of eastern U.P. and northern Bihar and the tropical regions of South India, though the tropical regions provide the most favourable habitat to the crop. This challenge offered by the great diversity of climatic factors, soil conditions, availability of irrigation resources in different tracts of the country during the past years has been met by the scientific talent with promising results. The work of the scientists has greatly supplemented the Government control measures for the development of the Industry which followed in the wake of the controls. The demands for sugarcane of the right quality by the expanding milling industry have been met to a great extent by the varieties of Co. canes bred at the Sugarcane Breeding Institute, Coimbatore. These canes have placed with the cultivating community a large number of new varieties with creditable milling performance. The varieties are at present serving the Indian milling industry and some of them have actually acquired international status. The cane research stations situated in the different States have taken up these varieties for testing their suitability to their local climatic and environmental conditions. These State stations have worked out detailed schedules concerning varietal, manurial, virigational, crop protection and other requirements of the crop and their recommendations have amply justified themselves through increased production wherever these schedules have been properly applied.

Low acre–yields

In spite of all that has been done so far, it unfortunately remains a fact that taking the country as a whole or even a State as a whole, the improved acre-yields obtained in Government sugarcane farms or in the fields of progressive cultivators or in sugarcane crop competitions are not reflected in the average acre-yields of the States or the country as a whole. Taking the example of Bihar State itself, whereas progressive cane growers here have obtained yields as high as 2,900 maunds (nearly 107 tons) per acre, the average acre-yield in the developed zones is only 18·8 tons. The yield in the non-developed areas outside the sugar factories is even lower at 12 tons per acre while the State average-yield is only reported to be eight tons per acre, as recorded by the Revenue Department. These figures relate to the years 1955-56. The all-India average also remains at the low figure of about 14 tons per acre while yields as high as 127·8 tons per acre (Bombay), 60 tons per acre (U.P.) and 94 tons per acre (Madras) have actually been obtained. The competition results have been more striking still since Madras in 1954-55 obtained an yield of about 129 tons and Bombay in 1955-56 about 138 tons per acre.

Further, in comparison with other progressive sugarcane countries of the world we have still to go a long way in improving our acre-yields; and more important still is the question of sugar recoveries. As against the average acre-yield of 14·7 tons and about 9·50 per cent recovery on cane in India, the corresponding figures in foreign countries are:

Country	Acre-yield	Recovery per cent
Egypt ...	30·42	9·97
Java ...	56·20	11·49
Peru ...	41·14	12·33
Hawaii ...	62·05	10·46

The improvements in the quantity and quality of crop produced have to be borne in mind by the research section and the full utilisation of the potentialities shown by the sugarcane varieties available has to be the constant aim of all development and extension services in the States. The more important sugarcane States like U.P. and Bihar started sugarcane development departments even earlier than the initiation of the Sugarcane Development Schemes sanctioned by the Indian Central Sugarcane Committee in 1948. These schemes include (i) supply of disease-free seed of high yield and improved varieties of cane at subsidised rates to the cane growers; (ii) adequate supplies of manures and fertilisers to the cultivators' fields; (iii) plant protection service and recommendations of control measures against pests and diseases; (iv) construction of pucca roads in factory areas to improve the transport of cane from the fields to the factories etc. The co-operation of the States and their officers in charge of sugarcane development schemes is essential so that the target of covering the entire sugarcane area under the development schemes during the Second Five Year Plan period is achieved.

Pilot Projects

It will be of interest to you to learn that at the recommendation of the experts, certain campaigns have been organised to run as pilot projects—the eradication of the Gurdaspur borer in a selected area in Jagadhri in Punjab and of red rot in a selected area of the Bagaha sugar factory zone in Bihar; two epidemic zones for these diseases have been taken up. Plans are also being finalised for another campaign to eradicate red rot from areas of severe attack in U.P., Bihar and Punjab. The importance of sugarcane as a cash crop, as a raw material for the sugar industry and the value of *gur* and sugar to the common man as articles of food, demand concerted efforts to make the cultivation of sugarcane a profitable proposition.

Expert Sub-committee's Report

If improvements and expansions are necessary so far as sugarcane development is concerned, the research aspects also need some re-orientation. I would be able to say about it with more complete information when the report of the Ad-Hoc Expert Sub-committee of the Indian Central Sugarcane Committee becomes available. This Committee after visiting the different States and critically reviewing the work under progress will suggest ways and means of making sugarcane research work more effective and fruitful. However, a few things which strike me as a lay-man are mentioned for your consideration.

Variety—The Pivot

Since variety is the pivot around which the sugarcane and sugar industries revolve, attention to this aspect is urgently called for. There are no suitable varieties for certain areas capable of withstanding the rigours of climate—temperature, scarcity or abundance of water, water-logging or possessing established immunity and resistance to diseases and pests. In some areas the number of suitable varieties is extremely limited. This position is not very satisfactory. Ithas also been observed that in certain varieties the period of fruitful life has been cut short and resistance has run down with consequent loss both in acre-yield and recovery. It is for the experts to suggest how the scope of varietal trials could be expanded to achieve the desired results, or what changes should be introduced in the technique of sugarcane breeding. Then, varieties are needed which would be particularly suitable for *gur* making. The demand for *gur* would always remain heavy and the *gur* industry, as a cottage industry, will continue as such for many years to come in spite of all the progress made in the white sugar manufacture. I will strongly urge that the problems of *gur* should be studied mainly with the object of finding out how the product could be improved by an individual worker or a small group of workers who would never have the facilities which a sugar factory provides. As a matter of fact I am surprised to see that there is not a single paper dealing with jaggery. Investigations regarding the quality of *gur*, colour and texture and improvement in *gur* and *khandsari* making at all stages of their manufacture, are pending and call for detailed studies. Sugarcane ratoon, popularly termed as the 'gift crop', is economically very helpful to the cultivators and perhaps with careful attention, it could be maintained at a proper standard of cultivation. This item should also be continuously studied so that suitable recommendations regarding varieties and other cultural operations flow from the research stations to the sugarcane growers for improving their ratoon crop.

Recent Advances

Very encouraging results have been obtained by mist-spraying of cane in transit in railway wagons or by moist trash blanketting of sugarcane carts. In both cases losses in yield and recovery have been reported to be appreciably reduced. Improvements in sugar recoveries have also been reported by harvest

control in succession of ripening of varieties. Further improvements in this respect would benefit both the cultivator and the miller. Pre-harvest spraying of the crop with 2, 4-D opens out a new avenue for study of harmones *vis-a-vis* sugarcane plant growth and its metabolic processes. The control of pests by their parasites, i.e. biological control, has been reported to be very successful in other countries and further investigations in this line with regard to our own climatic and environmental conditions should be pursued.

With these few observations I wish the Conference all success and once again express my gratitude to you, Sir, and the workers at this Conference.

SUGARCANE BREEDING AND BOTANY SECTION

PRESIDENTIAL ADDRESS

Re-orientation of Breeding Programme at Coimbatore

By

N. L. Dutt

(Director, Sugarcane Breeding Institute, Coimbatore)

Introduction

I FEEL highly honoured to be called upon to address you a second time as President of this Section so soon after the last Session. In my last address I had touched upon a rather wide range of items of work of the Breeder and Botanist and have no intention of covering the same ground here. I will content myself with drawing your attention to how we are attempting at Coimbatore to re-orientate our work in certain lines of research. In this I am much indebted to my able colleague Shri R. R. Panje with whom I have had very fruitful discussions and who has so ably helped in shaping this year's breeding programme at Coimbatore.

In more senses than one this is perhaps a swan-song for me personally, so far as scientific addresses are concerned, but believe me when I say that, however good an account a research worker may have given of himself in his life, when he comes to render the last account, he realises more than ever before how much still remains to be done. In my case, fortunately, I have had the privilege of working with able colleagues, whose devotion to varietal work and sugarcane improvement in our country is only equalled by their regard for the Coimbatore Institute; and I hope that the ground we have covered in sugarcane breeding and its connected problems during the past years will form a good foundation for future work.

Before I deal with the points I have promised to speak on, I may be permitted to make one or two general observations. In the present juncture of India's economy sustained effort is required on the part of everyone to achieve the targets of the Five Year Plan and in our sphere, in particular, to achieve greater production of sugar at less cost. There is a great need, I feel, for proper co-ordination of activities in the cause of crop improvement of sugarcane. Whatever may be your field of special interest, whether Agronomy, Cane Development, Mycology or the like, you all have your place and part to play. " They also serve who only stand and wait ".

I will now deal with certain scientific aspects of the work at Coimbatore and how we propose to re-orientate it. In what follows, I am in a way merely thinking aloud.

Breeding and Selection at present in Vogue

The system of breeding and selecton followed by us at this Institute is based more or less on the principle of effecting recombinations of the latest selections obtained by crossing earlier-proven canes. In the course of the breeding work, a number of recombinations get proved and these and the commercial canes of each stage remain in the crossing programme for a time before the more recent selections take their place as parents. This is a natural development in sugarcane breeding work, and sugarcane breeding in most countries has tended to acquire this complexion. Although this is a sure and the most economic way of getting commercially suitable varieties, it is possible that in the long run the maximum utilisation of gene-recombinations will have been made and the emergence of increasingly superior genotypes would thereafter become rarer and rarer.

New Genes and Genetic Stocks

The only way in which this possibility can be guarded against is by a steady influx of genes from related species or from new material of cultivated sugarcane collected from the original sources of the species. This implies a series of fundamental crosses, involving the use of the available sources of new genes. In this respect, as you all know, the Coimbatore Institute did pioneering work in the early years. I would not be far wrong if I were to say that perhaps more interspecific and intergeneric crosses were made and possibilities of out-breeding more widely explored at Coimbatore than at any other station. It is true that the results were not in all cases equally striking or uniformly fruitful; but in some cases at least, the breeder's expectations were more than fulfilled, and the gene-combinations derived from these crosses held the field for a whole quarter of a century. It may perhaps be profitable now to explore these sources and other known ones more intensively. Indeed, conditions are propitious now for giving more attention to this work, thanks to the extensive collections, assemblages and studies made on sugarcane germ plasm in recent years.

Sources of New Genes

(i) *Spontaneums:* There are three usable sources of new genes: the first is the spontaneums. Considerable amount of breeding has been done using the clones collected in the Spontaneum Expedition Scheme and it is a matter of credit that already two or three commercially-acceptable varieties have been obtained within the third back-cross. However, in this branch of breeding, attention has from the beginning been directed towards the selection of economic types, and it has not been possible to give attention in the progenies to the particular characters which are peculiar to the clone of spontaneum used in crossing. One of the principal objects of the Spontaneum Expedition Scheme was to find out the range of characters available from these stocks and to draw upon them for the hitherto unavailable genes which may be useful. The extensive studies made in the Spontaneum Expedition Scheme would not serve an important practical purpose if we do not make a discriminating use of the material in respect of the morphological, anatomical or biotic characters or features of special ecological adaptation possessed by them. It is true that in pursuing a programme of breeding with such genetic stocks, it is difficult to avoid the temptation of selecting economically suitable types; nor would it be right to deliberately throw away material in the progenies which is likely to have some commercial value. But at the same time, it may be said that if only economic types are pursued and no account is taken of the special characters exclusively possessed by the particular spontaneum variant used, we may miss some of the very important characters which may be needed by us now or in future. It is now time that the selection is given a bias in favour of the peculiar characters for which the wild clone has been employed in breeding.

(ii) *Robustums:* The second source of new genes is robustums. So far, we had certain difficulties in employing this source. Robustums flower rather poorly at Coimbatore, the clones themselves being badly affected by mosaic. Fortunately at Taliparamba, *robustum* is likely to remain free from mosaic. In this year's crop at Taliparamba, it has grown very well and some clones are already in short blade. A good beginning can therefore be made this year for using robustum-material.

(iii) *Officinarums:* The third source of genes is officinarums. Of course, all our commercial canes are derived from officinarums, but as a result of recent exploration work in New Guinea and the Polynesian Islands, a large number of officinarums has been procured and most of these have now been imported by us and added to our World Collection. One of our principal difficulties with officinarums here has been their general loss of vegetative vigour in propagation and their low flowering propensity. Here, as in robustums, the new clones from abroad and the location of the World Collection at Taliparamba have been helpful. Many of the imported officinarums from New Guinea, etc., are expected to come into flower at Taliparamba and crosses can be effected using appropriate spontaneums, robustums and Co. canes as male parents.

Inbreeding

Regarding the exact manner of utilization of the wild stocks in the fundamental breeding work, we have at least two possible ways along which to proceed. One is the consolidation and intensification of the desired characters in the wild stocks by inbreeding. Since both sugarcanes and wild canes are heterozygous polyploids, the characters are very elusive in progenies, and inbreeding to be effective would therefore take a few generations. In sugarcanes, this process has a limitation because it entails a loss of vigour. Such would probably not be the case in wild canes and we can therefore concentrate on characters available in the wild canes so as to get wild inbred genetic stocks which will confer the desired character for which the variant has been inbred as well as vigour on the crossed progeny. In pursuance of this idea, the selfing of certain spontaneum variants was started last year in the Spontaneum Expedition Scheme, and about 300 seedlings obtained from these selfs will be tested this year. There has been no loss of vigour in the F_1.

Penultimate Stage Genetic Stocks

The second is that genetic stocks should be built up by nobilization of wild stocks, and that the successive back-crosses with *officinarum* should in each case be brought down to one stage short of commercial acceptability. That is to say, if on the average a spontaneum or robustum requires to be backcrossed to officinarum up to the F_3 stage before the progeny reach commercial acceptability in the fundamental crossing work, the selection of genetic stocks should be made from among the F_2 individuals by means of comparative analyses of F_3 backcross progenies. These genetic stocks, if any, of the F_2 generation should thereafter be maintained in a small number as parents for immediate use when needed as stocks capable of conferring the specific desirable characteristic to their progeny. The present situation in our work is that, although we have a vast range of germ plasm and we have carried out the work of breeding with this material down to the stage of economically-suitable types, yet if at any time we have to have recourse to this wild germ plasm for the sake of any particular character, say resistance to ratoon-stunting disease, or short-season cropping we have to go all the way back to the wild stocks, search and sift the material and start nobilising it: under these circumstances, the very first tangible results can be expected, if at all, only after three or four back-crosses which will take as many years. All that is suggested is that the spade-work in anticipation of future needs should be done now: for this a list of such genes as we may require in the course of the next five or ten years should be first prepared; the Botany Section should select and pass on wild cane clones known to possess these selected genes. The selected stocks should then be nobilized and progeny assessment carefully carried out at each stage with special reference to the genes listed. As said above, this nobilization should be carried out up to the stage of commercially acceptable progeny, and the parents selected on the basis of tests on these final progenies. These selected parents should thereafter be maintained clonally for use whenever necessary.

Inbreeding of Co. Canes

Inbreeding of officinarums, as said before, has a limited scope. But a limited amount of inbreeding can perhaps be carried out in Co. Canes. Work done in Queensland and Barbados has given indication that through inbreeding it is possible to shift the mode of progeny performance in respect of certain characters. It has also been shown that certain inbred officinarums when used as males are particularly useful for incorporating richness of juice in their progenies. The practical utility, if not the principle underlying these methods has been questioned. But I do not propose here to enter into the controversy between the Hawaiian and the West-Indian viewpoints. The system is one which has come to be followed as a natural development of cane-breeding work and experience gathered in all the breeding stations in the world; and no doubt it has given uesful results and justified the breeding work done to date. But it cannot be denied that we have to bring about an increasing amount of order and systematization in the work of sugarcane breeding and gradually eliminate to the extent possible the element of hit-or-miss in it. It is conceded that inbreeding is confronted with many difficulties. The question of self-sterility is there; more important than that is the loss of vigour in the selfed progenies, and above all there is the prospect that it would lead to a loss of variability in the progeny. According to Hawaiian workers, this cuts at the very root of sugarcane breeding work, and would deprive breeders of the one vital feature which has sustained varietal improvement during the past 75 years, viz. production of greater and greater variability in the progeny.

It is true that, for the time being, variability would be reduced in the inbred material, but variability is by no means all thrown away and lost for ever from our material. There would of course be some losses. Our first losses would obviously be the deleterious recessives; the desirable characters can always be preserved by selection and stored away in a homozygous condition. But even granting that certain desirable recessive genes are lost in the inbred material, we can always go back to our heterozygous, unselected material, to the wild canes and to the hybrids, which we shall still have with us. Inbred material would be only an additional asset and not the replacement of the existing material. Once the required parents are produced by inbreeding, the desired commercial types can be synthesised easily with the proper use of the selected genetic stocks. As regards vigour, it is not unreasonable to suppose that such vigour as is lost in inbreeding would also be regained by the progenies as soon as the inbred stocks are crossed; indeed, possibly it would return redoubled in the progenies. There would be an understandable difference of opinion if it is suggested that the existing programme of economic crosses should be straightaway replaced by inbreeding. But there is no suggestion of this sort. All that is proposed, is that a beginning should be made in this direction by the unit concerned with the fundamental aspect of breeding so that, if possible, with suitable inbred stocks built up and desirable characters intensified in new parental material, we may in the course of the next five to ten years hope to reduce the element of chance in sugarcane breeding.

CONCLUSION

The above indicates in the main, the directions in which we are attempting to re-orientate our breeding work. I have not touched upon the proposals which we have for irradiation of sugarcane material to induce mutations or the directions in which we wish to augment our other activities. I now take leave of you and wish you all success.

SUGARCANE DEVELOPMENT SECTION

PRESIDENTIAL ADDRESS

Are we on the Right Lines in Sugarcane Development Work?

By

Dr. R. D. REGE

AT the outset I must express my appreciation of the opportunity given to me by the President of the Indian Central Sugarcane Committee to serve you as President of the Sugarcane Development Section and I crave your indulgence and co-operation in running this session to a successful conclusion.

Although the acreage under sugarcane forms an insignificant part of the total cultivable area of the Indian Union, the sugar and *gur* industry occupies a pre-eminent position in the economy of the country, as the prosperity of millions of cultivators is vitally linked with it. According to the official statistics published by the Government of India there has been over 53 per cent increase in cane acreages during the last 25 years, while the increase in acre yields is conspicuous by its absence. Although one may question the accuracy of the Government statistics there is no doubt that we are faced with the fact of low acre yield and low quality of cane as compared to other sugarcane producing countries of the world. We have thus to make great headway in development work to improve both the cane yields and the quality of cane.

DEVELOPMENT WORK IN PROGRESS

Since its establishment in 1944 the Indian Central Sugarcane Committee has not only intensified the research activities originally initiated by the Indian Council of Agricultural Research, but in addition has launched a developmental programme to translate the results of research into farming practices. During the First Five Year Plan the development schemes, according to the paper by M/s. Chandra and Sharma before you, covered an area of more than seven lakh acres by the end of 1955/56, mainly in the sugar factory zones, and the increase in cane yield as a result of the adoption of the various items of improvement was estimated as six tons per acre in U.P., Bihar and Punjab, 11 tons per acre in the Deccan Canal area of the Bombay State, 13 tons per acre in Madras and 10 tons in Andhra State. Crop-cutting experiments conducted in 1954/55 on an area of 6·25 lakh acres under intensive development in the States have shown the average yield of 23·8 tons per acre as against 13·9 tons in the entire area of 39·94 lakh acres. There is thus, no doubt that as a result of this developmental work there has been an improvement in yield but its full impact on the total production of cane cannot be properly judged till the method of collection of official statistics is improved by the Government of India. The Planning Commission had fixed a target of 631·8 lakh tons of cane production to be achieved by the end of the year 1955/56. According to the official forecast the total production of cane was 580 tons lakh only or about 51 lakhs tons less than this target in this year. If, however, the increase in yield of ten tons as obtained by crop-cutting experiments over 6·5 lakh acres is taken into consideration, we might have actually exceeded the target laid down by the Planning Commission.

For the Second Five Year Plan period the Planning Commission has fixed a target of 780 lakh tons of cane. Assuming that the acreage under cane is maintained at the same figure of 45 lakhs throughout this period, as per official statistics for the 1956/57, an yield of 18 tons of cane only per acre as average of this whole area will be required to ahieve this target. This amounts to an increase of about six tons of cane per acre over the average yield shown in official statistics, and this has been achieved already in the areas under development schemes sponsored by the Indian Central Sugarcane Committee during the First Five Year Plan. In view of the fact that similar developmental work has been now undertaken by the Committee in the whole cane area, I am confident that we will not only achieve the target as fixed by the Planning Commission but will even exceed it.

Criterion of Production

I have, however, to protest strongly at the criterion adopted by the Planning Commission as well as the Sugarcane Committee for the improvement of production per acre. From what I have described above the emphasis is entirely on the increased production of cane and not of *gur* or sugar. The data of the cane competitions run by the States at the instance of the Sugar Committee to bring out the potentialities of sugarcane production, given by M/s. Chandra and Sharma in the paper before you, do not give any information about the sugar content of the canes and in the case of some, if not all of the States, even the cane crop under cane competition is not tested for its quality. It is a fallacious argument to say that increased production of cane would be tantamount to increased production of sugar or *gur* and everyone of you must have come across instances of high production of cane resulting in poor quality.

The East India Distilleries and Sugar Factories Ltd., Nellikuppam, has been running crop competition tests during the last three years on the basis of sugar per acre. In this, however, quality of cane has been given due consideration in that the competitor must show a C.C.S. higher than ten per cent of the average C.C.S. obtained during the days his cane was crushed. It is interesting to note that a number of growers did not come to this standard although they produced higher cane tonnage than those who got the prize. The emphasis on increased production of cane laid both by the Planning Commission and the Sugarcane Committee is thus fraught with dangerous possibilities of cane production showing very poor sugar in cane, specially in the present context of payment for cane by tonnages only.

Sugar—the Criterion in Countries Abroad

Recently, thanks to the Parry Group of sugar factories, I had the opportunity of visiting a few cane-growing countries abroad such as Queensland, Fiji, Hawaiian Islands, British Guiana, Trinidad, Louisiana and Florida. It was very refreshing to note that in none of these countries did I come across research or development workers talking of production in terms of cane, and this mental set-up of theirs has influenced not only the research and development in these countries, but the attitude of cane growers as well. Breeding is directed towards the evolution of high quality canes and only such canes, as produce equal or higher yields than the existing ones are released in general cultivation. Low-quality canes, although vigorous in growth are even dropped from further testing and multiplication and, in consequence, they do not see the light of day to attract the attention of the cane growers. In consequence there has been greater improvement in the quality of cane than in cane production in these countries. In Queensland while the average production of sugar per acre for the five years ending 1919 was 2·05 tons requiring 8·5 tons of cane to produce one ton of sugar, it has been 3·50 tons of sugar for the five years period ending 1954, with 7·2 tons of cane for one ton of sugar. In other words, with an increase of slightly two tons of cane per acre additional production of approximately 1·5 tons of sugar is obtained.

Variety is not the only factor which has contributed to this improvement in sugar production. The high efficiency attained in the field in preliminary deep cultivation, proper fertiliser practices and co-ordinated measures to control pests and diseases has also its due share in this improvement in sugar production. Mechanical cultivation with tractors is now the general practice in almost all these countries and, in some, high-power tractors are used to shatter completely the sub-soil by running the subsoiler with prongs capable of going 22 to 27″. This is pulled across the field in one direction, then on the one diagonal and then on the second diagonal. Thus when the field is completed it has been ripped in three directions and the soil profile is relatively undisturbed. While some of the countries visited by me are characterised by plantation farming there are others, such as Queensland and Louisiana, where individual farmers cultivate cane. They are, however, well-equipped with machinery, either individually or co-operatively, for carrying out cultural operations mechanically. In Trinidad the plantations assist the individual cane grower in the proper cultivation of their soils.

In the manuring of cane, chemical fertilisers are used in all these countries and adequate care is taken to have a proper proportion of major nutrients. Nitrogen alone is never used, although its value in increasing the cane tonnages is well realised by the cane growers. It is very interesting to note that phosphates and potash form a large proportion of fertilisers and the dose of potash in some of these countries even varies from one and a half to two times the dose of N. Soil analysis or leaf diagnostic technique form the basis for manuring each field. Except in Hawaiian Islands where cane crop continues for two years and lodges badly, the fear of lodging in cane also serves as a deterrent against the use of heavy doses of N, as lodging not only deteriorates cane quality but increases the cost of harvest as well. In Queensland the cane grower will have to pay 50 per cent higher rates to cane cutters for lodged canes while he loses seven to eight shillings per ton of cane in price for one degree fall in C.C.S. per cent.

Crop Production Abroad

Crop protection against pests and diseases is another important aspect which has been receiving the greatest co-operative attention in these countries. Breeding programme aims at the introduction of such varieties only, as are resistant to prevalent diseases. Co-ordinated and co-operative efforts are, however, made to eradicate immediately any pest or disease in case of their incidence. In Queensland cane pests and disease control boards with five members are constituted for any pest or disease-infested cane area, three members of which are elected by local cane growers and the other two by the mill owners of the area. These boards, which are 18 in number, are responsible for supression of any cane pest or disease in their areas. They are authorised to pay subsidies for the materials used for the control measures adopted and to levy a charge up to 6d. on every ton of sugarcane received at the sugar mills in their area. Half of this levy is borne by the growers and half by the millers. In Fiji, excellent control of pests and diseases is also being maintained and during my visit I was surprised to learn that about five acres of young cane was uprooted and burnt owing to the appearance of Fiji disease. In Louisiana, the excellent work done by the Baton Rouge University on pest and disease control had been so much appreciated by the cane growers and there was such a keen demand for advice as well as materials required for crop protection work that the University Professor resigned his professorship and started private practice as it has been highly remunerative. The plantation countries have huge organisations for the control of any pest or disease and in consequence their incidence is practically negligible. Often one could find the samples of the pests or diseases of the locality either in the musium or experimental farms only.

Steps necessary to Improve Developmental Work

Against this background of work in countries abroad directed towards the improvement of sugarcane industry let us consider our own developmental programme. Initially, when the indigenous varieties which were generally poor in both cane yield and sweetness, were being cultivated by the ryots, varieties introduced by the Coimbatore Breeding Institute were definitely superior in both these characteristics. The introduction of Co. canes in general cultivation on the basis of cane yields only was thus quite justified at this initial stage. Now that the Co. canes have entirely replaced these indigenous canes in the commercial crop, the continuation of the same policy has been, I am afraid, adversely affecting the sugar recovery. This would be evident by scanning the figures of recovery of sugar per cent cane of the different States during the last ten years. Except Bombay, where the sugar industry is mainly on plantation system, all other major States such as U.P., Bihar, Punjab and Madras have been showing a downward trend. In Bombay, the introduction of the high-yielding Co. 419, which replaced sweeter canes such as E.K. 28 and POJ. 2878, had initially brought down the sugar recovery, but by proper adjustment of planting and manuring of this variety these plantations could achieve the improvement in sugar recovery. The story is, however, different in the case of this variety in Southern States, where the individual cane grower is responsible for the supply of cane to the factory. The climatic conditions are very favourable for growth and the variety responds to heavy nitrogenous manuring, resulting in high tonnages of cane but with low sucrose content. In the present context of the payment of price on cane weight basis irrespective of quality, the cane grower is, therefore, keen to cultivate this variety due to its capacity to produce high cane-yields. It has been thus an uphill task to introduce other varieties such as Co. 527 and 449 to replace this, although higher quantity of sugar per acre, due to better C.C.S., can be obtained by their cultivation.

Need for High-quality Cane

With the expansion of the sugar industry a greater and greater proportion of cane is diverted to the manufacture of sugar and, in 1955-56, 32·79 per cent of cane was utilised for this purpose. It is expected that by the end of the Second Five Year Plan about 50 per cent of the crop may go for sugar manufacture. In the manufacture of *gur* the crusher juice is merely concentrated and, as such, with the low-quality cane the production loss is not so high as in the case of sugar manufacture from this cane. In the interest of national economy, therefore, it is imperative that our aim should be to use less and less cane tonnages to produce one ton of sugar. When the country goes in for the system of payment on quality basis it would no doubt serve as a good incentive to the cane ryots to prefer the cultivation of sweeter canes than those giving high cane tonnages only. This is, however, an ideal, which, under the present conditions of sugarcane cultivation consisting of small growers, may take a number of years to achieve. Will it not be thus advisable for all of us to reorient our views on selection of varieties, as once a vigorous low-quality cane reaches the cane grower it would be extremely difficult to wean him from continuing to grow this variety ? Once adequate returns to him in terms of cane yields are fixed according to the tract, selection of varieties should aim to give him such a return, bringing in, at the same time, higher production of sugar per acre. The introduction of high-quality canes in general cultivation is specially essential in the South where the climatic conditions are more favourable for cane-growth than sucrose-formation.

Manuring vis-a-vis Cane Quality

It is a well-known fact that manuring exerts a predominant influence on the quality of cane. The old system was to grow cane mainly on F.Y.M. or compost, supplemented by oil cakes. Chemical nitrogen was hardly used and where it was used, it formed an insignificant part of total N. As both F.Y.M. and oil cakes, contained, besides nitrogen, other nutrients required by the plant for proper coordination of cane and sugar formation, the system of manuring was not in any way harmful except that it did not serve in securing high cane yields. Since 1954 the Government of India have started a campaign for intensive manuring of sugarcane with sulphate of ammonia alone and an area of 1·79 lakh acres was treated in U.P., Bihar and Punjab. During 1955-56 an area of 8·06 acres was similarly covered in all the sugarcane growing States in the Indian Union. A target of 15 lakh acres has been fixed for this scheme of intensive manuring for the current year. In order to encourage the cane ryots sulphate of ammonia is being given on loan.

The increase in yields obtained by the application of sulphate of ammonia has been estimated as 35·5 per cent in U.P. and 25·6 per cent in Punjab. There has been, however, no attempts to see how far this system of manuring has affected the cane quality. The demonstration of such spectacular increase in yield is, however, sure to tempt the cane ryots to go into the use of increased doses of this chemical nitrogen and to give up his old system of manuring. This encouragement to the cane grower to go in for chemical N alone by offering it on loan will have thus dangerous potentialities, specially in the South, where this scheme of giving sulphate of ammonia on loan is also extended. It should be realised that all the Southern States are highly nitrogen-minded and already adequate or even higher doses of N are being used by them. The climate is more congenial to the growth of cane than for sugar formation. The risk of lowering the cane quality with this intensive system of manuring with chemical nitrogen alone is thus obvious. The use of chemical nitrogen is not only economic but will result in the release of a large quantity of oil cake, which can be diverted for the feeding of cattle. But in this case one must be particular to recommend balanced fertilisers containing at least the major nutrients of NPK.

Importance of Foliar Diagnosis

In our country recommendations of fertiliser mixtures are still handicapped by the lack of information about the actual fertiliser requirement of the plant in different soils. It has been my experience—and it must be an experience of many of you—that the conventional methods of soil analysis depending upon extracting soils by chemical reagents are often unsatisfactory, particularly in the case of sugarcane. This is not to be wondered at when one takes into consideration the long period of vegetative growth of the cane and the great fluctuations to which the nutrient status of the soil is subjected during this time. Hence, nowadays, in almost all the intensively cultivated regions, soil analysis has been amplified or replaced by foliar diagnosis. I need not dilate on this system of foliar diagnosis as most of you must be familiar with it. I would, however, like to emphasise that both the research and development workers should give this method a fair trial as, according to the experience of advanced countries, it has excellent potentialities. I would, in fact, suggest that the I.C.S.C. should direct every State Sugarcane Research Station to give priority to the problem of determining standards for the major nutrients and should establish plant diagnostic laboratories at suitable centres for advisory work to the cane growers. It should be stated that the system of foliar diagnosis is not to be used for applying the fertiliser only after taking the leaf sample. While an initial fertiliser application can be made by the growers immediately after planting or after cutting of the ratoon, the cane leaf samples are to be used for correcting existing deficiencies which the basic application failed to correct. The cane ryot is thus likely to get correct advice on the fertilisers to be used by him before he completes his manuring of the crop.

Crop Protection Service

Another essential item of the developmental programme as laid down by the I.C.S.C. is crop protection service. With regard to some of these pests or diseases the loss in weight of cane due to their incidence is not so appreciable as to induce the cane grower to adopt the remedial measures. The damage is often to the cane quality in which the grower is not, at present, so interested. Besides, sporadic action by some individual growers is ineffective in the eradication of pests and diseases, as infection may be easily carried by the adjoining plots not so treated. In many of the States, Governments have on the Statute Book what is called the Insect Pest and Plant Diseases Act, which Government can apply to any area where coordinated action is considered necessary. In actual practice, however, the Government machinery cannot take effective steps due to the absence of willing cooperation of the growers. This cooperation would be only possible if he is roped into the working of the Act on the lines of the Queensland Boards referred to above, in which three of the five members are elected by local cane growers. These Boards will have to be also established for small areas

and as in Queensland authorised to levy a definite charge on every ton of sugarcane and utilise this amount for subsidising the control measures.

In the case of diseases each State Sugarcane Research Station should be equipped with pathological laboratories to test the resistance of the varieties received from Coimbatore to the prevalent diseases in the locality before putting these under further trials. Once the policy of the introduction of disease-resistant varieties is strictly followed, the disease-control in the fields would be mostly of academical interest. In Hawaii the breeder puts forth a resistant variety immediately any new disease is observed and the pathologist rarely comes in the picture in its control. As with the increased air communication between Fiji and Hawaii there has been the risk of transmission of Fiji disease in Hawaii, a testing station has already been established in Fiji to test the promising varieties against Fiji disease by the Hawaiian Sugar Planters' Association. It is thus essential that the varietal testing programme at each State research station should give a great deal of importance to disease-resistance as well and no variety should be released by this station, which is susceptible to any of the prevalent diseases of the locality concerned.

Another factor of importance in cane and sugar production is timely irrigation combined with early manuring. This is of the utmost value, specially in the South, where climatic conditions are not quite favourable for sugar formation in cane. Demonstration trials conducted at Samalkot in Andhra Pradesh under tube-well irrigation have shown on an average an increase of three tons of cane per acre and over 0·75 per cent of C.C.S. in cane . At Nellikuppam in Madras State early manuring under the same irrigated conditions showed an increased production of 0·36 tons of sugar per acre with no increase in cane tonnages. According to Government statistics, next to Punjab, Andhra and Madras States have the highest area under canals from rivers, and during recent years sugarcane has become an important crop on these canals. It seems, previously these canals were mainly intended for irrigating paddy crops and accordingly a system has been in force of closure of the canals for a period varying from one to two months during summer for desilting after the winter crop of paddy is harvested. It is unfortunate that in spite of large acreage under cane cultivation on these canals this old practice of stoppage of canals for such a long period is still continued. This not only adversely affects cane growth but further increases the incidence of borers. The cultivators are also prone to delay manuring till the onset of monsoon due to this insecurity of irrigation during the summer months. If these States adopt intermittent stoppages for short periods as followed on the canals in the Deccan Canal tract I am sure there will be an appreciable imporvement in both the cane tonnages and quality of cane in these States, resulting in increased production of sugar per acre.

Conclusion

I may, therefore, conclude my address with an optimistic note of achieving the targets of increased production as fixed for the Second Five Year Plan. However, in the above dissertation I hope I have been able to postulate the urgent necessity of changing the criterion of cane per tons per acre adopted at present by the National Planning Commission and the I.C.S.C. for increased production to sugar tons per acre. This, I am sure, will rightly influence the mental set-up of both the research and developmental workers, who are responsible for guiding the cane growers. The introduction of high-quality cane, facilities for timely irrigation, application of balanced fertilisers preferably on the basis of leaf diagnostic technique, and co-ordinated measures for the control of pests and diseases would pave the way for an appreciable increase of sugar production per acre at the end of the Second Five Year Plan, as these measures will definitely improve the C.C.S. per cent in cane. It is, therefore, my humble submission that in this Conference all of us should emphasise the importance of these aspects which are to result in increased production of sugar per acre, and would be of immense benefit to the nation as a whole.

AGRONOMY AND PHYSIOLOGY SECTION

PRESIDENTIAL ADDRESS

Some Reflections on Agro-biological Research in India

By

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I CONSIDER it an honour to be called upon to address this eminent gathering of scientists assembled here from all corners of the country. We are today in the happy position of assuming export status in white sugar, with prospects for capturing foreign markets in the indigenous product as well, and can doubtless feel

gratified with this fruit that our endeavours over two decades have borne. To catch up with the more advanced sugar countries of the world, we need to greatly intensify our efforts and there can be no two opinions about our attaining that stature in the not too distant future. I shall attempt here to narrate in brief the position reached by us in agro-biological research in sugarcane and in that context venture to offer certain suggestions which, in my humble opinion, would lead to the progress we are all aiming at.

The foremost need of sugarcane research is the evolution of better varieties combining high tonnage and superior quality with resistance to pests and diseases and various adversities of environmental condition like floods, water-logging, droughts, frost and cold as also adaptability to various types of soils. This aspect is by far of greater importance than any cultural improvements that may be effected, inasmuch as the latter largely depend on existence of various types of facilities and availability of finance which the cultivator in the major sugar belts sadly lacks. The varietal aspect thus calls for all-out efforts, and in this connection the need for intensified endeavour both at the breeding centres and at testing and subsidiary stations can hardly be over-emphasised. The position is particularly unenviable in the North Indian sugar belt, which is surcharged with disease inoculum and has been on more than one oaccsion threatened with extinction of the Industry as a result of major canes being swept away in various parts of the tract. In the tropical South, Co. 419, the " wonder cane " of peninsular India has shown signs of virus infection in recent years. A scrutiny of the varietal position in the different States would indicate that releases made in the early thirties still hold the field and canes evolved later have made little headway. This can be traced to a sense of complacency arising out of continued good performance of the earlier varieties even after years of cultivation under none too good cultural conditions. It is, however, disconcerting to visualise the impact on the Industry of a possible calamity striking some of the present-day dominant varieties in the shape of disease or physiological deterioration. In fact, deterioration of Co. 419 in recent years has occasioned serious anxiety in the Bombay-Deccan and although tided over for the time being by adopting measures like change of seed, a possible future recurrence of the trouble may mean that the entire peninsular tract is left without a cane to support its Industry. The need for stand-by varieties equally good in performance is thus an imperative one.

Variety Test Gardens

Fortunately quite a few of the new varieties, particularly Co. 775 and Co. 798 in the Bombay State, and Co. 678 and Co. 810 elsewhere, have indicated sufficient promise and these need to go for large-scale testing under the widest available ranges of soil and climate. At the present moment, the greatest shortcoming in the varietal sphere is the unduly long interval that intervenes between the release of a variety and its final adoption for cultivation or otherwise. The pressing need, therefore, is to cut down this lag very materially so that newer varieties synthesised after further experience may have a chance for trials in the near future. A uniform system of testing all varieties from Coimbatore and elsewhere at all the research stations in the country has likewise to be evolved with annual circulation of results to all research centres to enable periodical assessment of performance under diverse conditions. Similarly, a careful testing by each station of all commercially promising varieties, no matter where they may have been evolved, has to be introduced. The testing must be done under the widest possible scatter in the region served by each station. The establishment of, at least fifty " variety test " gardens in each sugar producing State, functioning in close co-operation with the breeder, the tester, the miller and the grower is also an urgent desideratum for the quick selection of outstanding canes every year, followed by large-scale multiplication and release for general cultivation. In this process of selection, certain minimum standards have to be rigidly adhered to in the matter of tonnage and quality and all material falling short thereof, ruthlessly rejected. However, material showing any valuable traits other than these attributes would also need to be preserved. Now that the Indian Central Sugarcane Committee has decided to try out important commercial varieties from foreign sources for direct adoption in this country and the Coimbatore Institute has already made a beginning in this direction by issuing a few of them to the State Research Stations, the procedure envisaged above would be particularly important. The institution of an All-India Varietal Council, representing all interests concerned in the improvement of the Sugarcane Industry, to serve as a watch-dog of the varietal position in the country would be a great progressive step in this connection. This is particularly important if we have to draw upon the pool of knowledge relating to varieties available at any time and to safeguard against propagation of varieties found susceptible to red rot disease and the like.

Aspects of Varietal Selection

I would also like to draw pointed attention to certain other aspects which need to be developed in connection with varietal selection work. First among these is a study of varieties under controlled conditions with regard to their reaction to various adverse conditions that may be encountered in nature, e.g. floods, water-logging, drought, salinity of soil and so on. Such conditions have to be artificially created to conform

to fixed specifications instead of depending on their occurrence in nature in varying degrees. By this means, the varieties passing through the whole series of such tests would have revealed their true reaction to the various factors with regard to physiological and biochemical performance. Secondly, all varieties should be thoroughly screened against red rot and smut—the two diseases that are causing at present the heaviest losses in the northern and southern sugarcane belts. The latter of these two gives well-defined indications of resistance or susceptibility. In the matter of pest resistance, there is little evidence to show that a variety otherwise superior in standards has been kept back because of its high susceptibility to a pest. And yet elaborate observations are recorded, not necessarily on a uniform basis at the different stations to assess such ratings. It would, therefore, be worthwhile considering as to how much of this work could be cut down to be profitably spent in more fruitful directions; also whether varieties in all stages of filtration viz. nursery, of observation plots, pre-finals and finals should be subjected to assessment of this kind. Even in the case of screening against diseases, it would appear that it is the final trials that really matter, for after all, it is one or more varieties out of these that will ultimately find their way into general cultivation. Further, as in nature incidence would vary in different years, the best course, would appear to be to study this resistance in lysimeter-cages, releasing known populations to get "effective" values, both where the host has choice of varieties and where it has not, simultaneous testing being provided under field conditions to work out correspondence between the different ratings obtained. Moreover, the technique of assessing resistance to different pests also calls for appropriate scrutiny. Where it is intended to determine loss in weight and quality in relation to incidence figures, when a unit rise means a certain decrease in the two economic attributes, recourse would need to be had to correlational analysis and appropriate regression equations.

Effect of Frost

Studies on frost resistance have largely been qualitative. In years of severe frost, the crop suffers both physical injury as well as chemical deterioration, especially under conditions of low soil moisture. Field observations have revealed that crop with poor growth, thin stand and having suffered from lack of irrigation facilities or timely rains is the one to go under as the temperatures fall below 32°F. On the other hand, well-nourished crop given irrigation during frosty spells suffers little damage even when the temperature goes below 28°F. Continuous frost proves more harmful. Temperature of 28°F. or below kills all leaves, growing point and the majority of buds above ground, even rendering a substantial part of underground buds unfit for germination. The lodged crop and the early harvested crop suffer heavy bud mortality. The stalks are completely water-soaked at the tip and base as well as for most part along the rind. The quality of juices is also affected adversely. Irrigation before and after proves useful to save the crop from injury. Formations like mannite and dextran have been reported, and the latter is known to cause considerable difficulty in working the low-grade juices. Even acetic acid formation becomes a factor of major importance in factory technology. Since the deterioration of sugarcane after a killing frost depends so largely upon weather conditions, especially the average daily temperature, these need to be compared with those of the same period of the previous year when no frost was experienced. Resistance to frost is governed largely by the physico-chemical properties of tissue fluids. It is also affected by the ease with which the plant is able to withstand dessication, denaturing of its proteins, quality of pentosans, mucilage, and pectins contained and the rapidity with which sucrose is converted to glucose during frost. Cell-size appears to be definitely correlated with resistance to frost and so also two protoplasmic characters—permeability and consistency change with its alteration. The work therefore has to be well-planned, under competent direction.

There can be no gainsaying the fact that limitations with regard to facilities for optimum manuring and culture have stood in the way of full expression of potentialities of improved variteies. Provision of those facilities depends on many factors, some of them likely to be serious limitations for some time to come, and the immediate aim should be to raise progenies that would be poor feeders and yet give of their best in tonnage and quality. With the present advancements in plant breeding, such an attempt should bear fruit. Meanwhile, all varieties under test should be subjected to conditions of high, medium and low fertilisation, and correlation studies undertaken with respect to their physiological and biochemical behaviour under these sets of conditions. Such a course would enable a proper understanding of the reaction of varieties to differences in fertility level and enable appropriate selection from this point of view.

"Running-out"

The "running out" of important varieties has not infrequently occasioned concern. Sugarcane is a vegetatively propagated crop, and as such it is not a true variety but a clone which is static. The soil environment is, however dynamic and the reasons for running out have, therefore, to be sought in the factors making for soil fertility unless, of course, the disease factor complicates the picture. The possibility of heavy demands by the crop on major and minor nutritents on specific soil depths is also obvious and, in fact,

degenerated varieties have been found to yield well on specially fertilised beds or in new fields where the variety in question had been not grown. The results obtained in peninsular India by changing of seed have already ben referred to and the idea of reinforcing seed material by special nutritional or other treatments is gaining ground.

With the limited or almost non-existent irrigation facilities in many parts of the country so far available, choice of varieties was largely limited by consideration of drought-resistant characters. With the wide extension of these facilities, the range of choice should now expand in a great measure. In this connection, it would also be necessary to undertake work under controlled conditions to asses response potentials to irrigation, not only with regard to yield, but in respect of the physiological and biochemical aspects of the crop. This has to be followed by correlational analysis to elucidate the mechanism of varietal reaction to differential levels of water. Besides studies on the physico-chemical properties of tissue fluids, those on transpiration/evaporation and plant metabolism (respiration) and detailed work on cell-size characteristics are called for. Leaf analysis in respect of sugar concentration and soluble proteins besides moisture loss in cut leaves and shoot/root ratios would also appear important.

Menace of Red Rot

Red rot continues to be a major menace in the main sugar belt of North India and the succession of more and more virulent strains that have appeared in recent years poses a major challenge. The susceptibility ratings worked out in relation to a particular strain have failed to hold good for the new strains and this introduces an element of uncertainty in the process of release of varieties. It has therefore become imperative to initiate work under controlled conditions with a view to artificially inducing mutations and testing all varieties in relation to the most virulent of the races emerging thereby, in the hope that in this way it will be possible to dodge nature in prolonging the life of usefulness of new varieties.

Seed Nurseries and Varietal Census

To achieve a satisfactory varietal position, establishment of seed nurseries and varietal census are essential pre-requisites. A chain of central seed nurseries and sub-zonal nurseries has to be created along with a body of seedmen, specialising in seed cane with high glucose content and other desirable features making for high yield and quality. Provision should also be made for reinforcement of seed by special nutritional or other treatments and chemo-therapy of setts involving treatment with organo-mercurial fungicides like Aretan and Agallol. Varietal census is equally important to saturate the area with approved varieties and completely eliminate undesirable or discarded ones that lead to lower production and perpetuation of diseases.

Manurial Practice

Manurial practice varies largely in different parts of the country, the tropical belt using heavy dressings of nitrogen—300 to 450 lbs. in Bombay, followed by 200-350 lbs. in Madras—and raising a heavy crop. In the sub-tropical North, where yields are lower, doses are 120-200 lbs. with irrigation and barely 100 lbs. under unirrigated conditions. So far, phosphate responses have been obtained only in Bihar and parts of Madras, as also in rare instances in the State of Bombay. Potash manuring has been considered fruitless on the whole. However, experiments on cultivators' plots have revealed in recent years pockets of marked potash response in different parts of the country and also definitely indicated a much greater scope for phosphate manuring. An important development has been the successful use of anhydrous ammonia as a cheap source of nitrogen in Mysore which gives crop yields comparable to those under Ammonium sulphate application. Improvements of this nature are of particular benefit for the poor average cultivator in this country. Side by side with the use of artificials, the maintenance of organic matter content in the soil is of special importance. Green manuring is a universal recommendation in this connection, phosphate manuring of the green manure crop being advantageous with regard to yield and quality of cane. Growing of green manure crop *in situ* along with cane and burying it in furrows after six to eight weeks of growth is also being practised with advantage in certain parts of the country. Use of sulphitation press mud has become popular, as also cane trash, either directly incorporated in the soil or with a small quantity of ammonium sulphate, cowdung or press cake. Carbonation press cake proves useful in the amelioration of soils showin gtendency to development of acidity. Application of molasses has proved economical where it can be pumped directly into the soil after dilution with water.

A significant development in recent years has been the appreciation of the importance of experiments on cultivators' fields as the only sound basis for making recommendations, and such experiments are now being conducted in most States under wide scatter representing the entire range of variations in soil and

climate. The whole series of T.C.M. experiments has been modelled on this basis. The need is to complete an intensive soil survey of the sugarcane tracts during the next few years and link up the manurial responses to the soil units isolated, ultimately building up an advisory service to guide the cultivator in respect of varietal, manurial and irrigational requirements of a particular soil unit.

Crop Nutrition Studies

In crop nutrition studies, a judicious combination of organic manure with inorganic fertilisers has been found most conducive to long-term maintenance of sugar yields. The early juvenile stage of the plant is the most active with regard to nutrient uptake, a secondary peak being also observed later in the life-cycle. With the development of foliar diagnostic technique, plant analysis as a guide to proper fertilisation is receiving increasing attention. The most suitable tissue to be sampled in this connection, however, needs to be properly worked out with reference to the varying conditions in different tracts of the country. The introduction of crop-logging would appear to hold out considerable promise, particularly in plantation estates, as a means for optimum utilization of water and manure. Similarly, rapid tissue-testing procedure needs to be developed in the country for quickly assessing the nutritional deficiencies in plants. Foliar application of nutrients has indicated considerable promise in other countries and experiments are called for on a wide scale to assess its potentialities as a means for cutting down fertiliser costs and as a solution for the problem of restricted phosphate availability and trace element activity in many Indian soils. Methods of phosphate placement, application of phosphate through carriers and use of pellet and briquett fertilisers needs further experimentation. Intensive work would also appear necessary with regard to balanced nutrition in relation to soil types to attain high tonnage with improved juice quality. The supposed incompatibility of high yield and quality is operative only after a certain stage in yield expression has been reached and even at this or a still higher level, balanced nutrition can enable attainment of both. Use of radio-tracer technique in following the fate of added fertilisers would be helpful in a solution of the nutritional problem in general.

Cultural Improvements

Shifting of planting date to afford an increased growth span to the crop is perhaps the most important cultural improvement effected. This has been conducive to both increased yield and sugar and in large parts of tropical belt of India, there has been a large switch-over to *adsali* (18 months') crop in place of the older *eksali* (12 months' crop). North India is also rapidly taking up autumn planting with good results. Reduction in gap intensity by lowering distances between and within the rows of the crop is also a modification contributing to higher production. It is now generally accepted that three-budded setts are most economical and give best results. Good germination has been associated with high glucose and amide nitrogen, optimum moisture content, good undried buds, setts with high nutrient content and break-down of natural hormones. Various pre-planting treatments have been devised; important among which may be mentioned the use of organo-mercurial fungicides like Aretan. These bring about great improvement in germination, tillering and stand. Work on crop rotation on systematic lines is now an urgent need. Paddy—sugarcane rotation has been followed in the South over long periods, and still the yields of cane do not appear to suffer. Study of the economy of different crop cycles has therefore to be taken up on long-range basis with reference to conditions in different parts of the country. Similarly, problems of ratooning require to be studied in greater detail as definite possibilities have been indicated with regard to achieving ratoon yields even higher than those of plant crop under favourable conditions of culture. Aspects calling for particular attention are the mode and time of harvest of parent crop, maintenance of crop density, time and quantity of fertiliser application besides quality and frequency of cultivation and irrigation water to be provided.

Work on weedicides has mainly centred round the trial of different formulations as pre-emergence and/or post-emergence spray to control different kinds of weeds. Although some of the broad-leaved weeds are effectively controlled, there is little or no success achieved as far as annual and perennial grassy weeds are concerned. The subject, however, is of great importance and calls for a well-considered plan which will provide information on the incidence and intensity of weed flora in different seasons in sugarcane crop as also in others that come in rotation with it; effect of treatment on the control of different weeds, residual effect of pre- and post-emergence sprays; frequency of treatment in the control of pernicious weeds, soil movement of 2, 4-D, periodical regeneration of weed flora both in plant and ratoon crop. These require careful layout and chemical, biochemical and soil studies.

The expansion of irrigation facilities in recent years has opened up great possibilities for improvement. In the greater part of the North Indian tract, what has existed so far is at best a " protective irrigation " just sufficient to enable the crop tide over stress periods. The " productive irrigation ", so essential for maximising sugar output per acre, is now going to be available. Want of sufficient moisture in the soil has stood

in the way of optimum responses to fertilisation and it is found that with a suitable variety under adequate manuring and irrigation cane yields as high as 52 tons can be recovered in North India and 76 tons in the South. Other advantages of irrigation are better land use, additional and more remunerative cropping, improvement of cane quality by reducing the pith-cavity formation and maintaining storage tissue in good condition besides normalising the wide fluctuations that at present occur in the quality factor. The realisation of ratoon yields as high as or greater than that of plant crop is another possibility of great significance which could be achieved by optimum culture and adequate manuring under irrigated conditions. Unirrigated ratoons have higher fibre content and show greater field driage than plant crop; irrigation would help in reducing fibre content, raising juice extraction and lessening field driage.

Irrigation Control

Present-day irrigation control consists in following the depletion of soil moisture through moisture tension curves, the appropriate tension being used as an indicator of the time of irrigation. Procedure of this nature would need to be developed in different parts of the country and the necessary equipment got together as early as possible. Use of evapo-transpirational measurements for determining irrigation intervals from meteorological data would likewise need to be examined. This consists in finding factors affecting loss of moisture by evaporation and transpiration and enables mathematical computation for each fixed climatic location with no gross variation from season to season. This approach has the advantage of easy operation with very little cost. Application of radio-isotopic methods in elucidation of wetting patterns and related aspects can also be usefully employed. Overhead sprinkler irrigation has also be to examined. It is reported to give enhanced yield with superior juice quality, besides cutting down the quantities of water used. If successfully employed, this system would greatly facilitate spray application of fertilisers, insecticides and fungicides.

Irrigation of standing crop in the late season phase has been found to minimise tonnage losses by field driage besides reducing deterioration in quality by inversion of sucrose under the conditions obtained in Northern India. This affords a very economical method for conservation and best utilisation of the crop. It has also been found that scheduled crushing of cane in order of maturity, pre-assessed by refractometer surveys of standing crop, enables an enhanced output of sugar. Similarly, methods have been devised for keeping cane moist during the period of transit to the factory which lead to considerable conservation of available sugar. Foliar and soil application of plant hormones has likewise been found to step up the sugar content of crop. Much scientific work is, however, called for to follow up the role of hormones in plant metabolism in order to elucidate their mechanism of action and to assess the extent to which their efficiency can be raised. Radio-tracer studies have already thrown some light in respect of other species of plants and application of this fruitful technique should result in fuller knowledge of the effects of hormones on growth and sucrose assimilation in sugarcane.

Fruitful Lines of Research

Further research aiming at maximisation of sugar production per unit of land has to be intensified on various lines, most important among these being the evolution of suitable treatments for improving germination and stand of crop; fixing the optimal nutritional level and balance of the major nutrients for different tracts; fixing water requirements of different sugarcane varieties for each area; irrigation control by moisture tension curves and evapo-transpirational methods. Study of nutrient-soil moisture interactions in relation to physiological attributes; study of trace elements and hormones in relation to growth, developmental performance, yield and quality (2, 4-D and boron sprays have already indicated great promise in the matter of improving quality); trials on aerial sprays of water and nutrient solutions at a particular stages of crop starvation; study of carbohydrate and nitrogen metabolism of sugarcane with a view to elucidating nutrient absorption and assimilation; growth correlation studies to assess progress of development and ascertain abnormalities in the correct exposition of growth vigour; analysis of resistance characters of varieties in relation to drought, water-logging and floods, besides frost and cold, and appropriate distribution of resistant varieties based thereon; study of the physiology of salt and alkali tolerance and varietal distribution in tracts based on tolerance characters; further work on weed control; use of growth inhibitors to suppress flowering so as to minimise loss in sugar; foliar diagnosis to test fertility level and periodically check up manurial schedules; and introduction of crop-logging after fixing up normal curves in respect of each factor for every tract and systematic check up of physiological run of crop throughout the growth period so as to afford necessary amelioration at the appropriate stage. Another important aspect requiring attention is the induction of flowering in non-flowering varieties and controlling time of flowering in those which flower—a problem of particular importance in relation to the breeding programme. Fundamental studies have likewise to be undertaken, aiming at analysis of the basis of flowering as also of the phenomenon of apical dominance, the

latter including studies on the role of growth-promoting and inhibiting substances in inducing early and vigorous tillering. Correlation studies between temperature and sunlight (both duration and intensity) on the one hand, and crop growth on the other, would similarly have an important bearing on the improvement of cultural practices. Lastly, micro-climatic studies on crop-weather relationships would be another fruitful line of investigation.

Analysis of Data

A reorientation appears to be called for in the planning of observations recorded by the different research stations so as to retain what is really of primary importance and then to interpret their significance by adequate correlational analysis. Thus, considerable chemical data are being gathered in agronomical trials but no clear picture has emerged as to what they have led to and in what precise manner they are to be utilised for improving the efficiency of production. The fate of N, P and K has rarely been followed; nor are supporting investigations on C:N metabolism being conducted in general. Similarly, biometrical studies in growth and height have indicated varying degrees of relationship with final yield but the mass of data collected has seldom been subjected to correlational analysis. This would appear to be very necessary to gain useful knowledge for future application. Basic studies leading to identification of factors that either inhibit or promote desired growth would be more fruitful than the present routine recording of observations in all agronomical trials. Recent indications that nitrogen and the green or dry matter contents of cane leaves can be used to predict relative crop yields should be of special interest. Further, in view of the importance of non-sugars in determining manufacturing quality of juices, a routine assessment of varieties in this regard would be particularly important.

SUGARCANE CHEMISTRY AND SOIL SECTION

PRESIDENTIAL ADDRESS

The Role of Sugarcane Soil Studies and Chemistry in the Planned Development of Sugarcane in India

By

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I AM deeply conscious of the responsibility devolving on all of us engaged on studies of the sugarcane soils with a view to bringing about a phenomenal improvement in the yield and quality status of our sugarcane crop, so that the Indian Sugar Industry might expand on a rational basis and grow to much greater heights. It is thus a matter of great privilege to me that I should once again be called upon to guide the deliberations of the Sugarcane Chemistry and Soil Work Section of this All-India Conference of Sugarcane Research and Development Workers.

In my last Presidential Address I discussed the theme of " Soil Classification in Relation to Sugarcane Development ". Today I propose to deal with the more important features forming the future lines of our work on as wide a front as possible.

Our average acre yield of sugarcane is reported to be 14·1 tons as against 62 tons of Hawaii and 50-66 tons in Australia, Cuba and Mauritius. Our recovery is only 9·98 per cent as compared to 14·3 per cent of Australia and 12 per cent of Cuba. Thus while some of these countries produce 6·5—7·5 tons and over of sugar per acre we produce only about 1·4 tons. Again, with a total area of about 4 million acres, which is equivalent to 35 per cent of the cane area of the world, we produce only five million tons out of the 24 million tons of cane sugar produced in the world, i.e., only about 20 per cent of the total world production. These figures would clearly indicate that much yet remains to be achieved for maximum production through research and development. For the Second Five Year Plan the targets fixed are 74 lakh tons of *Gur* and 22·5 lakh tons of sugar in 1960-61, against our current production of about 58 lakh tons of *Gur* and 19 lakh tons of sugar.

One way of achieving these targets could be by increasing the acreage of sugacane. But we cannot afford to do this, since we are short of our requirements of food grain soil-seeds, cotton and jute. The majority of our sugar factories are located in the North where the yield is lower than what it is in Peninsular

India. Soon after the year 1931-32 when the Sugar Industry started establishing itself in India on a large scale, as a result of tariff protection being granted, most of the factories happened to be located without adequate planning, or due consideration being paid to the suitability of the areas selected for intensive cultivation of sugarcane over long years. Shifting the factories now from the North to the South where climatic conditions are more favourable for higher production, does not sound either a feasible or a practical proposition. Our future programme of work would thus necessarily be limited to the following two major items:—

1. Introduction of new varieties which should be of high tonnage and high sucrose content, and also resistant to attack of diseases and pests.

2. A very efficient programme of soil management for ensuring the maximum yield and high quality crop, and maintenance of high fertility level.

It is obvious that the sugarcane breeders can no longer perform miracles, as they did during the first three decades of the present century. Thus there is now an urgent need for modifying our present policy of sugarcane breeding and release of varieties.

It has become almost a normal practice these days to release varieties for a tract, purely on the basis of the temperature and rainfall pattern and without much consideration of the soil characteristics or capabilities. It is an established fact that within a climatic zone there is a differential performance of varieties, and these differences could be accounted for by variations in the soils, manurial treatment and cultural practices.

In the past the Soil Chemist had been relegated to the background in the release of varieties. The result was: too many varieties being recommended for a tract, which not infrequently led to confusion on the part of the grower who many a time got varieties which did not come up to his expectation because they were not suited to the type of soils on his farm. Hence, the importance of releasing varieties by taking soil types as a unit in a climatic region cannot be over-emphasised.

Objective Soil Survey and the important role of Trace Elements

This leads us to the subject of soil survey and soil classification. Survey of sugarcane soils has been in progress in this country for about the last two decades. Every year there is a demand for taking up new areas. This indicates the keen interest the growers and the industy are taking in soil survey work.

The very phrase "survey of sugarcane soils" connotes that the survey is objective or purposive. Soil survey work undertaken for pedological characterisation of soils would involve a detailed study of the soil-forming processes and the factors of soil formulation, so that the soils could be assigned their appropriate place in the World Soil Classification Scheme. The task of the Pedologist is thus over. But the sugarcane soil worker has another mile-stone to cover. His job is to measure quantitatively the various factors which lead to a satisfactory assessment of the physical productivity of the various soils. It may be observed that a large number of physical and economical complexities prevent satisfactory measurement of these attributes. Existing soil surveys are in general not readily adaptable to a determination of functional relationships between soil properties and productivity of sugarcane soils, chiefly because normally soil properties are not given suitable quantitative expressions. The need for developing a method for obtaining a reduced number of critical properties on the basis of which it could be possible to quantitatively characterise the soil as a physical medium for sugarcane growth and not merely as a chemical or fertility medium is very much indicated.

Every year increasing number of instances of trace element deficiencies are coming to light. We now know that certain elements present in very small quantities in the tissues are essential for the healthy development of the plants. These trace elements are Boron, Copper, Manganese, Molybdenum and Zinc. But trace elements are of interest not merely beacuse of their biological significance. More detailed study of their behaviour will undoubtedly provide clues to the several unsolved pedological problems.

The trace element content of a soil is dependent almost entirely on the processes of weathering—both geo-chemical and pedo-chemical, to which the soil-forming materials have been subjected. Work in Russia, Macaulay Institute in U.K. and the U.S.A. do not suggest any simple trend in the content of different trace elements in soil profiles, which might directly be ascribed to pedological processes. The factors that govern separately and jointly the distribution of trace elements in the soil profile include the weathering processes, leaching of soluble constituents as in podzolisation and leterisation, movement related to gleying and associated oxidation-reduction effects and variable water-tables, plant extraction and surface enrichment, and also the cumulative effect of the activity of the soil micro-organisms. Thus in our programme for soil survey a detailed study of the profile distribution and the trace elements should also be included. The zones of deficiency and toxicity could thus be spotted, and data emerging from field experiments on the response of the sugarcane crop to trace elements could be scientifically interpreted. Efforts should also be made to estimate qualitatively and quantitatively the trace elements removed by the crop and also those added to

the soil through the application of fertilizers and manures. By working out the relationship of trace elements to soil pH and the macro-elements, mainly calcium, we may hope to have all the prerequisites for the quantitative appreciation of the need of trace elements for the growth of the crop.

Soil Survey Programme

I would now suggest for your consideration and future action an outline, as given below, of the steps to be followed in the survey of sugarcane soils.

1. The unit of study may be a sugar factory zone.
2. A reconnaissance survey of the whole area of the zone should be done in respect to parent material, variations in rainfall, topography etc. The range of variation in these factors will give a clue to the volume of work involved.
3. The next sub-unit should be a village where every variation in the surface soils may be recorded and correlated with various factors of soil formation.
4. If the holdings of farmers are consolidated, a farm should be taken as ultimate unit. If there are no consolidated holdings in the area, distinct variations in surface soils and topography will determine the number of profiles to be taken.
5. If the farm is taken as an ultimate unit, the performance of the cane crop, and manuring history and other relevant data should he recorded.
6. The next step should be the recording of all the morphological features, along with the pattern of topography and drainage conditions etc.
7. Besides the regular laboratory determinations (mechanical, chemical and physico-chemical) analysis for the profile distribution of trace elements should be undertaken.
8. Drainage water should be analysed for trace elements.
9. Crop-cutting experiments should be conducted on every soil type and the phases thereof. The data should be collected on yield, juice quality, and the composition of cane with respect to macro as well as micro-elements.
10. The correlations of these dependent variables should be worked out with some soil property or properties which could be useful for the purposes of prediction, besides indicating certain diagnostic characteristics.

Soil survey and crop-cutting experiments will provide us background information on fertilization, irrigation and drainage requirements of the soils and other soil management problems. But we cannot be specific on soil survey data for fertilizer recommendation. As I shall be discussing shortly in this address, specific information on such problems can be collected by adopting the " tissue-testing " techniques. Of course, the precision and scope of our work would be limited mainly by the number of trained workers available for such work.

Assessment of Manurial Requirements

Now I propose to discuss certain aspects of the manurial requirement of the sugarcane crop. While the need for nitrogen is general, phosphorus is needed only in a comparatively few cases. Hardly any response with potassium has been observed. It is only very recently that some response of the cane crop to the application of potash has been recorded in the North-West of the Champaran district in Bihar.

Sugarcane is a heavy feeder, and an average crop of 30 tons per acre removes from the soil 105 lbs. of nitrogen, 31·5 lbs. of phosphoric acid and 63 lbs. of potash. While in North India nitrogen is applied at 120—200 lbs. per acre, in Peninsular India doses up to 400 lbs. per acre are not uncommon. Nitrogen is applied partly in inorganic and partly in organic form. There are certain fundamental problems of soil chemistry. specially with reference to nitrogen, which when worked out would be of considerable agronomic interest. Bower in U.S.A. has observed that fixation or retention in non-exchangeable form of ammonium ion by clay minerals is of great significance under conditions of high temperature and frequent rainfall. This finding should be verified by us because of its agronomical implications.

We know that the nitrate form of nitrogen is the most fugitive constituent of the soil. On purely thermodynamic grounds, denitrification should occur in the presence of oxidisable carbon compounds even under fully aerobic conditions. Experimental proof of this has been furnished by Broadbent in California who found out that:

(a) low oxygen content is not a necessary condition for the process of denitrification,

(b) the rate of denitrification is affected more by the quantities of nitrate and oxidizable carbon than by the partial pressure of oxygen;

(c) and denitrification may occur even though fresh additions of organic matter have not been made.

I would appeal to you, fellow soil scientists, to work out quantitatively the different channels through which nitrogen is lost from the soil under different environmental conditions. This, along with the work of the Plant Physiologists, will throw light on the optimum period and the extent of nitrogen fertilisation of the cane crop. Recently N^{15} has been used in such studies in the U.S.A., and much valuable data have been obtained by mass-spectrometer scanning of the soil atmosphere.

Soil Type and Root Distribution

There is an interaction between the soil type and the pattern of root distribution. The geometry of root system assumes considerable importance in the case of soil nutrients like phosphorus, the distribution of which is not uniform in the different layers of the soil. If we work out the geometry of the roots of different varieties on a particular type of soil and try to correlate it with placement of applied phosphorus or with native phosphorus or different fractions thereof, I feel confident that we would succeed in collecting valuable data helping to solve the phosphorus riddle.

In view of the fact that there is hardly any response of sugarcane crop to potassium, the " potassium supplying power " of our soils should be determined. By a technique of continuous cropping with a very quick-growing crop like sunflower, we can find out how much of fixed potassium is made available to the crop. If such a study is made on light soils which have a poor potassium-fixing capacity, perhaps we would be in a position to locate such soils on which the sugarcane crop would show positive response to potassium manuring.

Techniques of Plant Analysis

I must confess that our fertilizer recommendations are indeed somewhat empirical and general, mainly because we have been depending for guidance on only one technique, namely, field trial. Now I propose to discuss the utility of the technique of plant analysis, as a valuable supplement to field experiments, in the determination of fertilizer requirements. This to my mind, would lead to results which would enable us to formulate our fertilizer recommendations with much greater precision than has hitherto been possible. This fruitful line of investigation should be taken up forthwith by all of us in our respective zones of activity.

Soil analysis gives us only "Intensity level", or "Chemical potential" of the nutrient ions in the soil. The transfer of nutrient ions from soil-water system to the plant has two broad facets, and soil analysis furnishes only one of them. The second facet is the absorption of the nutrient ions by the plant through its roots. The fifteen elements now considered as essential for the growth of higher plants cross the boundary between the soil and the plant by a multiplicity of processes. In a completely uniform distribution of nutrient ions in the soil. The geometry of the root system is the main link between the two facets. When the distribution is not uniform, the geometry of the scatter of nutrient ions also assumes importance.

Plant analysis has been undertaken in the past in different crops with the following objectives:—

1. Investigation of nutritional disorders made manifest by definite symptoms.
2. Interpretation of the result of field experiments.
3. Development of rapid testing methods for use in advisory work.
4. As a method of nutritional survey.

In Hawaii the determination of current nutrient requirements has been worked out mainly by the method of nutritional survey through plant analysis. There these techniques are followed mainly to assess the nutrient needs of the sugarcane crop, with a view to supplying immediately the deficit nutrients. Work in Hawaii on sugarcane has been coloured and complicated by the fact that, as in India, profitable levels for nitrogen application vary greatly with the climatic conditions in which the crop is growing; excess nitrogen may lead to serious decrease in sugar yield. This has led to a search for an index of assimilatory activity or carbohydrate accumulation, so that the balance between carbohydrate and nitrogen might be estimated. Clements and Kubota suggested that for sugarcane the sugar content of the young leaf sheaths would provide such an index " Primary Index ".

Plant or tissue analysis as a method for nutrition survey has also been used by Evans in British Guinea. This method is very reliable for assessing the levels of adequacy, inadequacy or toxicity of nutrients. Thus it may be observed that there is need for the following two techniques of nutritional survey through plant analysis being adopted by our sugarcane workers, with a view to solving satisfactorily and in full the problem of fertilizer requirements.

1. Rapid and specific spot test techniques. The determinations are qualitative, viz., high, medium and low; and

2. Quantitative analysis of tissues in the laboratory.

The first technique would help us in improving the crop growth by supplying immediately the deficit nutrients. The second technique is merely a method of nutritional survey over a large tract. There is no intention of remedying immediately any state of unsatisfactory nutrition found in the plants, but rather to apply the results for a better planning of fertilizer treatments for the subsequent crops.

These techniques have been adopted for sugarcane by Craig, Halais and Feillafe (1938-53) in Mauritius; Innes *et al.* (1949-53) in Jamaica; du Toit (1953) in South Africa; Bauchamp (1940) in Cuba; Bedsole and Breggor (1953) in Florida; Aughtry and Lunin (1953) in Dominican Republic, Bonnet, Samuels' Capo and Bangdiwala (1953) in Puerto Rico; Ayres, Borden, Hons, Clements, Bun and Humbert (1933-54) in Hawaii; and Evans and his colleagues (1954) and Birbett (1954) in British Guiana. The success of these techniques is also due to the fact that every effect is made to eliminate or render ineffective certain known variables.

While selecting a technique much spade-work will have to be done as regards the organ of the plant to be sampled and the stage of the development of the plant. Care must be taken for the preparation of the material for analysis, i.e., cleaning, drying, and grinding. We must, therefore, undertake detailed plant analysis for a comprehensive survey of the fertility status of our sugarcane soils. This would also be of considerable help in crop logging as well as evolving precise manurial schedules for the different sugarcane tracts.

Use of Radioisotopes

We hear much talk these days about radioisotope techniques. To some these techniques might appear to be the royal road to successful experimentation; while there may be others who are apt to look upon these with considerable cynicism—something like a fad, creating more problems than they would solve. But the truth lies in-between these two extreme views. Much useful data have been collected in the field of mineral nutrition of crop plants and chemistry of soils through the application of these techniques. In field experiments agronomists usually compare different treatments in terms of yield response. But in the case of radioisotopes no yield response is required, because we can have an idea of their relative merit from radiochemical data. The other advantage of radioisotopes is that they could either be used to compare the natural capacities of soils to supply the elements in question or to evaluate various added sources of these elements in a particular soil. But for successful application of these techniques it is essential that the research workers must be thoroughly familiar with elementary radiochemistry and radiation physics. I would accordingly recommend that the Government of India might be approached with a request to provide facilities for the training of competent Soil Chemists and Physicists in this fruitful line of research.

Soil Conservation

Last, but not the least in importance, is the problem of soil conservation. Under this term we not only include the control of erosion, but all such soil management practices which conserve and built up soil fertility, and check the spread of alkalanity and salinity. Sheet erosion on the sugarcane fields is our most insiduous enemy, and causes serious losses of nutrients, specially nitrogen and phosphorus. The phosphorus in the subsoil is generally lower in quantity and availability than that in the top soil. The replacement of organic matter with its nitrogen and phosphorus, therefore, constitutes the major problem in reclaiming eroded soils. The eroded soil will usually contain a greater total supply of calcium, magnesium and potassium than the original top soil. Another problem in sheet erosion may be the loss of silty or sandy surface soil, leaving a heavy clay layer exposed at the surface. Under such conditions erosion severely damages the soil; since the layer of heavy clay may not contain enough aeration porosity to support a good crop of sugarcane. The loss of top soil from strongly differentiated profiles presents a problem for which research has not yet shown suitable means of management. The undifferentiated profile is relatively simple to manage even if the top soil is removed. The management is largely that of replacing the organic matter, or fertilizing with nitrogen, phosphorus etc. after the top soil is removed.

For the prevention and control of erosion in sugarcane tracts we will have to divide the geographical area into Land Use Capability Classes, and this could be done at the level of "Soil families" in the system of soil classification followed by us. Unlike U.S.A., where they have eight classes, we can have the following four families:—

Family I. Agricultural land suitable for intensive development.

Family II. Land suitable for occasional and limited use.

Family III. Land suitable for afforestation or permanent vegetation.

Family IV. Not suitable for agriculture or forestry.

These classes are broad enough to be useful for the different organisations at present engaged in nation building activities.

Importance of Spacing

Sugarcane is a row crop and requires very clean interculture. The distance between rows, as recommended to the cultivators in different States, varies generally from two to four feet. Spacing is a function of the stand of the crop, type of the soil in which it is grown and the standard of intercultivation adopted for raising it. Due to use of machinery in intercultural operations, Agricultural Engineers have been advocating a wider spacing. Agronomists advocate a wider spacing on the consideration of the pattern of rooting. But there is considerable risk of losses through soil erosion in growing widely-spaced, clean cultivated row crops like the sugarcane. When the field is free of weeds and the soil has been pulverised by frequent hoeings, there will be a very heavy run-off with the onset of the monsoon, specially when the rows are parallel to the slope of the field. If the space between two rows is in the form of a trench, the danger is aggravated still more, because the running water attains higher velocity and can thus carry more soil in suspension. In sloping lands the rows should invariably be put perpendicular to the natural slope of the land. We should also conduct experiments to gather data on the magnitude of losses caused in term of plant food and the quantities of soil removed.

The improvement and management of saline and alkaline soils is of no less importance on our programme of work. Wherever we face the problem of salinity and alkalinity, the quality of irrigation water, irrigation practices and drainage conditions are involved. Fundamentally plant growth is a function of the total soil moisture stress which is the sum of the soil moisture tension and osmotic pressure of the soil solution. Through controlled leaching, the osmotic pressure of the soil solution should be maintained at the lowest feasible level: and by a practical system of irrigation the soil moisture tension in the root zone should be maintained within a range that is likely to give the greatest net return for the crop. These ends can be achieved only by a thorough investigation of the physical and physico-chemical properties of the affected soils.

To achieve the targets fixed in the Second Five Year Plan and to raise the efficiency of our sugarcane cultivation we need a very close team work among the plant breeder, the agronomist and the soil scientist. The new varieties evolved by the breeder should be tested by the agronomist for different ecological regions. But the final release of a variety for an ecological region should be only when it has shown promise under a particular edaphic habitat, taking soil type as a unit. This way, soil survey work will become a vital part of the sugarcane research organisation. The cultural and irrigational operations given to the crop should be such that they will build and conserve the productivity of our soils. This end could be achieved only when we have worked out the practices which are conducive to the operation of the natural " Law of Restitution ". In the field of fertiliser recommendation where today empiricism and generalisation are the rule, a close cooperation between the agronomist, the physiologist and the soil scientist will lead to a clear picture being obtained of the fertility status of our soils, the exact need for fertilisers and the practical methods by which we might diagnose and treat the crop suffering from malnutrition in the field. Once we have succeeded in finding out quantitative relationships between sugarcane yield and environmental, cultural and soil factors, the element of uncertainty will fade away in our planning. Then and only then we will do the best service to the cultivator and the industry.

SUGARCANE ENTOMOLOGY SECTION

PRESIDENTIAL ADDRESS

By

Dr. K. B. Lal

(Plant Protection Adviser to the Government of India)

I AM deeply conscious of the honour done to me by the President of the Indian Central Sugarcane Committee by nominating me as the Chairman of the Entomology Section of this Conference. I can lay no claim to being a research worker in Sugarcane Entomology, though I have had to be associated now and

then with the control of sugarcane pests. As such, I can hardly make any original contribution to your knowledge of sugarcane pests and shall consider myself fortunate if I can assist in your deliberations in any other way.

Since the last Conference was held in Jullundur in 1954, a fair amount of advance has been made in the study of sugarcane pests and the methods of their control in India. Publications have appeared which have summarised much useful knowledge about sugarcane pests and indirectly focussed attention on the problems still awaiting investigation. Interest in control campaigns has also been widened and intensified and some remedies have been confirmed as effective and economical. While the control of *Pyrilla*, grass-hoppers and termites is now more a matter of organisation than of technique, that of the borers, mites and some soil-inhabiting insect pests continues to demand attention in the both directions. As in the case of the pests of other crops, the chemical control of sugarcane pests at present occupies the major attention of sugarcane growers and scientists. Since the borers are about the most destructive of sugarcane pests and since they feed internally most of the time, insecticidal applications against them are not easy. A major requirement of any insecticide to be successful against borers must be its prolonged residual effect and this in turn must be coupled with an efficient pest intelligence service so as to overcome the difficulty of precise timings of spray programmes with hatchings or borer moth emergences on large scale. Likewise, the development of suitable ovicides against mites and soil insecticides or fumigants against soil-inhabiting pests are some other of our present requirements.

Biological Control

The borers, more than other sugarcane pests, remind us of the need to look to methods of pest control other than the merely chemical, howsoever useful the latter has proved so far. Hardly any efforts in the field of biological control of sugarcane pests have been made ever since the large-scale field trials with *Trichogramma* in different parts of the country, initiated by the Indian Council of Agricultural Research and subsequently taken over by the Indian Central Sugarcane Committee, were terminated about ten years ago. There may not be a case for re-enacting large-scale, field trials with *Trichogramma*, but surely there are other natural enemies, both indigenous and foreign, which deserve sustained and serious investigation. It is, therefore, very gratifying to find that interest in the biological control of sugarcane pests has again been revived and a team of Indian Entomologists may shortly explore in some foreign countries the possibility of utilising this promising method in India. Every venture in biological control, howsoever carefully planned, is not a success but, if one out of several succeeds, it more than pays for all the failures, apart from the benefit it brings by controlling any one pest.

Varietal Resistance

Although sugarcane varieties continue to be tested for their resistance or susceptibility to the attack of pests, the work can hardly be said to have afforded by any promise of practical relief in the field, any more than it did ten or even twenty years ago. The information is, however, useful in the initial selection of varieties, so that a highly susceptible variety may be discarded. Even though insects do not develop new strains, varieties and races as rapidly and as frequently as do the fungus diseases, it is doubtful to what extent reliance may be placed even on the initial selections to protect sugarcane crops from pest attacks.

Even though sugarcane is among the dwindling group of crops on which mechanical methods of pest control may be practised with advantage, the removal of infested shoots, the digging up and destruction of stubbles from the field after harvest, earthing up of the young plants, collection of egg masses, etc., wherever possible, would continue to provide appreciable protection from the attacks of pests, notably borers. However, mechanical and chemical measures of pest control in a grown-up like sugarcane crop present their own problems of application which should be considered relatively to their effectiveness and economics. A method of pest control must be suitable before it may be recommended for adoption by the growers and its suitability must be considered in relation to a great many more factors than merely effectiveness and even economics.

Increased Pest Outbreaks

A disquieting feature of sugarcane cultivation at present is the increasing risks of pest attacks to which the sugarcane crop is being subjected on account of a variety of factors. The clearance of new lands for cultivation, increasing use of fertilisers, different planting periods to permit crops standing in the field practically all the year round and the difficulties of giving up the practice of ratooning have all helped pest outbreaks. The Gurdaspur or Dehra Dun borer, *Bissetia steniellus*, is no longer confind to its original areas of infestation near Gurdaspur in the Punjab or Dehra Dun in the Uttar Pradesh, as was the case about 15 or 20 years ago. The top shoot borer has assumed serious proportions in recent years in the States of Bombay

and Madras. A new cockchafer beetle pest has appeared since last year in a localised area in Bihar, which has been extremely destructive and which may well spread over much larger areas, if not effectively checked. Rats have not been usually considered as pests of sugarcane, though in some areas and seasons they can be and have been as destructive as any of the other pests.

Estimates of Losses

Although pests have been causing damage to sugarcane crop practically all over India, reliable estimates of losses sustained by sugarcane growers as a result thereof are generally not available on any overall basis. One reason may be the difficulty of isolating the effects of individual factors which may adversely affect crop yields or juice quality. However, it should be possible to correlate the degree of pest incidences with the deterioration of the crop. Indeed, something of this kind has already been attempted in the case of the *Pyrilla* and the borers, but more needs to be done. It would be revealing and would help in increasing the efforts for the control of sugarcane pests if estimates of losses caused by them were made on some uniform and comparable basis by sugarcane entomologists working in different parts of the country. Likewise, frequent and scientifically planned attempts should be made to assess the gains in terms of yield and quality resulting from the adoption of large-scale control measures against pests.

Sugarcane is a crop which can bear a fairly high expenditure on the control of its pests. It is also a crop which, in some cases, is amenable to treatment by means of aeroplanes. It has been a notable feature of development in plant protection during the past few years that, along with the tests and use of new and modern insecticides, attention has been paid to the suitability of different types of ground equipment for spraying and dusting purposes. It is well known that control campaigns can be rendered ineffective or unduly expensive by faulty application equipment or techniques. Sometimes contradictory results have been obtained in the control of the same pest with the same insecticide, and sometimes results of research have lost much of their value because a large number of insecticides has been indiscriminately used in the trials. The need for some time appears to be to critically assess the effectiveness of the insecticides already tested against various pests and to draw reliable conclusions from them for the guidance of the sugarcane growers ; secondly, to test different machines for spraying and dusting sugarcane crops and to narrow down the range of their varieties and indicate their maximum utility during the different periods of the crop growth; and thirdly, to develop a system under which pest infestations on sugarcane crops are detected early and controlled in time. For this purpose, some kind of effective collaboration between research and extension workers, involving some good training of the latter, would have to be developed.

SUGARCANE PATHOLOGY SECTION

PRESIDENTIAL ADDRESS

Red Rot Epidemics in India and suggestions for their Control

By

Dr. B. L. Chona

(Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi)

I GREATLY appreciate the honour the Indian Central Sugarcane Committee have done me by asking me to preside over the deliberations of the Plant Pathology Section of the Third All India Sugarcane Research and Development Workers' Conference. With your kind help and cooperation, I feel sure that the deliberations of the Section would be a success.

There are about four million acres under sugarcane cultivation in India at present with a production of about 20 lakh tons of white sugar and 35 lakh tons of *Gur*. The targets set for the Second Five Year Plan demand considerable increase in sugar production in the country for home consumption as also the export, to earn some of the much-needed foreign currency. Considering the country's requirements of essential staple food crops there is little hope of increasing sugarcane acreage. The only way therefore, left to achieve the desired object is to concentrate upon the land we already have under sugarcane, to produce much more than what we are doing at present. Improved cultural and manurial practices would, of course, go a long way to help in the matter but there is also another aspect which, if dealt with properly, would most certainly add considerably to our annual output of sugar. It is that of Diseases and Pests. Sugarcane diseases cause

appreciable recurring losses, year after year to the cane crop. In addition, the industry has suffered heavily whenever diseases have assumed epiphytotic forms. There are several instances in the history of the World Sugar Industry where disease epidemics have brought the industry almost to the brink of ruin. Red rot of sugarcane is one of such diseases which has caused heavy losses in various countries. In India, Red Rot is the most serious disease of sugarcane, particularly in Northern India, which is the main cane tract of the country with about 80 per cent of the country's cane acreage, and has often proved a limiting factor in the successful cultivation of several high-yielding cane varieties. Off and on, the disease assumes an epidemic form. Since when this malady has been present in India is not very clearly known. Its presence, however, was felt, for the first time, when it broke out in a severe epidemic form in 1901, in the Godavari Delta, in Madras. In Champaran and Muzaffarnagar (Bihar) it appeared in 1906 as an epiphytotic. In 1922, there was a severe out-break of this disease in Jammu (Kashmir). In 1932, at Pusa (Bihar) severe infection occurred in the variety Co. 210. This was rather a sudden appearance of Red Rot after its almost complete absence for six years. A couple of years later, in 1935, heavy losses were reported due to this disease at Intiathoke, near Gonda, (Eastern U.P.) affecting Co. 213. A similar localised epidemic occurred at Nagina (Western U.P.) during 1937 in Co. 331 crop.

History of the Disease

The most unprecedented epiphytotic, however, in the history of Red Rot in the country occurred in Eastern U.P. and Northern Bihar during 1938-40, chiefly affecting Co. 213 and presented a new phase of the problem, as these canes were being looked upon as resistant to Red Rot. It resulted in complete devastation of thousands of cane fields of the most predominant commercial variety, Co. 213, in the affected tracts. The cultivator, as well as the factory were both hit very hard. The cane 'crush' in a number of mills in Eastern U.P. was reduced to about one-third of the normal amount in the 1938-39 season and to one-half in 1939-40, owing to poor supplies of cane. It was also observed that, contrary to the prevailing ideas, the epidemic was not confined to low-lying or ill-drained fields only. The disease subsequently spread in the cane tracts of Bengal, Orissa, Southern Bihar, certain parts of Eastern and Western U.P. and Eastern districts of Punjab. The variety commonly attacked, in most of the places, was Co. 213.

The sudden and wide-spread failure of Co. 213, which had served the industry faithfully for about a decade has an exact parallel in the failure of P.O.J. 213 in Louisiana, in the United States of America, during the 1930's.

During 1946-47, Red Rot broke out again in U.P. as a severe epiphytotic and this time Co. 312 was the cane-variety which was hit most severely. In the following years, Co. 313, Co. 453, and B.O. 11 were found to be widely affected in Northern Bihar and U.P. In the Eastern Punjab, the disease was most common in Co. 312 and Co. 313.

Modes of Infection

These epidemics and the havoc that they caused in the badly-affected cane tracts focussed attention of the country on this cane disease and called for more concentrated efforts towards finding an answer to the periodic recurrence of the disease and the methods for its control. Intensive research projects were taken up for systematic studies of the disease at the Indian Agricultural Research Institute and the various Sugarcane Research Stations. It was soon discovered, after careful examination of thousands of affected canes in different localities, that the 1938-40 epidemic could not be ascribed to the use of diseased setts alone,—thus necessitating a change in our old conventional views of "Healthy setts and no Red Rot"—and that some other factors, also, were operating. Research projects pertaining to sources and modes of infection, spread and perpetuation of the disease, etc. were taken up. Soil infection experiments clearly showed that considerable Red Rot infection can take place through infected soil even if healthy setts are planted; and that the Red Rot fungus can persist in soil and thus serve as primary source of inoculum. This inoculum is usually built up from the dried-up diseased canes and stubbles left over by the cultivators in the field at the time of harvest. Though the survival of Red Rot infection in the soil is limited, there is every possibility of soil getting repeatedly infected owing to existing cultural practices of cane cultivation, thus resulting in perpetual Red Rot infection in the soil. It was also established that even healthy setts, growing in a healthy field might give rise to a diseased crop due to infection brought in by irrigation water in the form of fungus spores, later in the season. These spores, on germination, infect the cane stalks through the nodal region near the ground level. It was observed that such infection during the months of July and August when the crop is about five to six months old, results in high disease-incidence. The possibility of its occurrence in nature is great, as during these monsoon months of high rainfall, mass movement of water from one field to another is quite common and infection from diseased fields may be carried to healthy fields.

Nodal infection of sugarcane stalks has been found to be an important factor which contributes towards the failure of a variety. It has now been experimentally established that the spores which get lodged in the cavity between the leaf-sheath and the stalk germinate readily and infect the nodes. The ruptured rind at the root primordial region and leaf-scars provide easy avenues for the entrance of the young infection-hyphae. The chances for nodal infection to occur are obviously ample: the spores produced in acervuli on the leaf mid-ribs may get washed down by rain water or dew to the base of the leaf. The cavity there, with arrested water, would serve as an ideal humid chamber, for spore germination and subsequent infection. Comparatively, tender nodes on the upper and middle portions of the stalk have been found to be more vulnerable to infection than those towards the basal portion.

This kind of secondary infection has been usually found to remain confined to the nodal region in the form of small reddish-brown specks just below the rind. The next season, however, when a sett with incipient nodal infection is planted, the young shoot gets infected from the very beginning and later may serve as a source of inoculum for secondary infection. The nodal infection is the chief means of field infection of the crop in nature and is responsible for the annual recurrence of the disease. The nodal infected setts are likely to pass off undetected as healthy at the time of selection for planting.

Varietal Susceptibility

Great differences have been observed among different cane varieties regarding their susceptibility to this mode of infection. The varieties which possess a comparatively greater resistance to nodal infection are likely to remain free from disease even if growing amidst plenty of Red Rot inoculum. Such has been the actual experience in the Red Rot epidemic affected tracts in U.P. and Bihar. The cane varieties which have shown appreciable resistance to nodal infection were observed to have remained almost free from Red Rot during 1938-40 epidemic even in the worst-affected fields. Furthermore, it has also been shown that this power of nodal infection is not possessed by all the isolates of the Red Rot fungus. Evidently the predominance of only such isolates that possess the power of nodal infection could cause any appreciable secondary infection of the cane crop and bring about an epidemic.

Nodel infection, therefore, could be used as an important test to determine the pathogenic power of the prevailing Red Rot flora of any particular tract and the resistance of the cane varieties grown therein to predict the possibility of the outbreak of Red Rot epidemic.

Contrary to the findings of the workers in the Western Hemisphere, that Red Rot infection passes from the diseased mother sett to the young shoot has been experimentally confirmed, thus supporting the views of Butler and other earlier Indian workers. It has been observed that diseased setts give poor stand and the young plants, invariably, are infected with Red Rot. Disease lesions have often been traced from infected seed-piece to the growing plant. It has also been found that the infection can take place through the cut ends of the setts or through growth cracks that occur in nature, on the cane rind.

Red Rot and Borer-holes

In Western literature, a lot of data has been presented regarding the importance of the borer-holes in the spread of Red Rot. In India, however, observations were made in the epidemic-affected areas, as well as in soil infection tests, conducted at Karnal, for three successive seasons. The data, thus collected, showed that in a large number of cases there was Red Rot attack in the absence of any borer injury, though in a few cases both Red Rot and borer attack were present in the affected canes. On the other hand, a very large number of cases have been observed where borer holes were present but there was no Red Rot infection. Furthermore, in many cases, where borer-holes were present in a Red Rot affected stalk, the origin of infection could not be traced to the borer punctures. Evidently the borers play little part in starting or spreading the disease in India, which again is quite different to the experience of Western workers. Recent reports from Mauritius, also show that a large proportion of Red Rot attack could not be correlated with borer injury.

Existence of Different Strains

Continual change in Red Rot flora presents yet another problem. Existence of strains different in morphology, pathogenicity or other physiological processes has long been realised in a number of sugarcane-growing countries. A light-coloured and highly sporing type of Red Rot fungus has predominated in the isolations made, during recent years, from diseased canes obtained from epidemic-affected areas of U.P., Bihar and Punjab, whereas, all the isolates in our collection obtained prior to 1938, are of a dark type with sparse sporulation. The new, light type isolate is more virulent than the dark type and by virtue of

its profuse production of spores it is naturally better suited for quick and widespread dissemination. As a result of tests with a large number of isolates it has, however, been found that there do not appear to exist any highly specialised physiologic forms like those of the wheat rust fungus, with definite specificity between an isolate and a particular cane variety or a set of varieties.

The Red Rot fungus has, broadly speaking, been classified into two groups mainly on cultural appearance, that is, light and profusely sporulating type and the dark and sparsely sporulating type. However, there appear to exist different biotypes within these broad groups. There are strains, for instance, within the light group, which differ in their virulence. The isolations made from Red Rot epidemic affected areas of U.P., during 1946-49, gave biotypes which were comparatively more pathogenic on Co. 312 and Co. 313 as compared to those obtained during 1938-40 from Bihar, which were responsible for throwing Co. 213 out of cultivation.

It clearly shows that there are different parasitic strains of the fungus and these are constantly arising in nature. At present, there are eight different strains reported to exist in India. These strains most probably arise by spontaneous mutations. New strains, specially those differing in their pathogenicity have been a great hurdle for the cane breeders to overcome. A variety is bred, tested and finally distributed in a particular cane tract where it is found to be suitable. It takes several years to saturate an area with an improved variety. It, however, does not appear to take too much of a time for a new strain of the fungus to develop and make the cultivation of the variety practically impossible. This is exactly what happened with Co. 213, in 1938-40, Co. 312 and Co. 313 in 1946-49 and recently with Co. 453 and B.O. 11 in U.P. and Bihar, in spite of their thorough testing for Red Rot resistance.

This obviously indicates the necessity to investigate as to how new strains arise in nature: how these get spread over large areas so quickly: how these can be detected and what are the factors which make a strain virulent or a variety susceptible. There are many more similar questions which require an answer to help in solving the problem of Red Rot.

WORK ON MUTANTS

The work in the past has shown that mutations arise in *C. falcatum* in old cultures, and when it is grown on a rich medium like Richards' Solution agar. Efforts are being made to produce highly virulent strains through induced mutations for screening the varieties. The work in progress at the Indian Agricultural Research Institute has yielded some interesting mutants by the use of beta-rays through radio-active Phosphorus and Fast Neutrons. One of these mutants, developed from a light strain (isolate No. 244), has completely lost its spore-colour: the spore masses instead of being pink, are creamish white. In another instance, the irradiated culture of isolate No. 244 produced a dark strain with a considerable change in the shape and size of the spores which is also virulent. In addition there are a few others which could be called nutritional mutants, produced in a similar way. The pathogenicity tests of all these strains are now in progress. Considering the great importance of such studies, the Indian Central Sugarcane Committee have sanctioned a special scheme at the Indian Agricultural Research Institute, for the study of the factors responsible for the change of *C. falctum* flora.

With constant evolution of new strains of the pathogen, the pressing necessity for the production of newer varieties of sugarcane is obvious. In India, work in this line was started by Barber, when he detected a certain amount of resistance in the thin indigenous canes (*Saccharum barberi*) and used it for crossing with susceptible noble canes. A vast amount of information is now available about breeding for disease resistance. Most of the cane varieties in cultivation now have two or more species of *Saccharum* represented in their parentage. The common parents of the most of the present day varieties are *S. officinarum*, *S. barberi*, *S. sinense*, *S. robustum* and *S. spontaneum*. Now *Sclerostachya* sp., too, is being considered as a possible parent. In India, *S. barberi* and *S. spontaneum* have been looked upon as sources of resistance to Red Rot, with varying degrees of success. The well-known difference between Kans (*S. spontaneum* of India) and Glagah (*S. spontaneum* of Java) regarding their differential response to mosaic infection, has given rise to speculations that there might as well be clones within *S. spontaneum* which would differ in their behaviour towards Red Rot. Abbott (1938) stated that "some forms of *S. spontaneum* may be resistant or possess resistance as a recessive factor".

A collection of *S. spontaneum* clones from different parts of India, as well as from some foreign countries, has recently been made at Coimbatore for breeding purposes, and some of them along with other *Saccharum* spp. in the collection have been tested for their resistance to Red Rot. Among other parents *Sclerostachya* is now being tested for Red Rot resistance with different strains of the fungus. In the trials conducted at Karnal, it has proved to be resistant to Red Rot, and, therefore, it might turn out to be a good source of resistance when used as parent in future crosses.

Breeding for Red Rot Resistance

Sugarcane breeding, due to the highly heterozygous and polyploid character of the plant, has been more or less a hit-or-miss affair, more empirical than scientific. The results of the Red Rot varietal resistance tests extending over several years provided sufficient information regarding the resistance or susceptibility of certain cane varieties to Red Rot. This basic information made it possible to attempt the breeding of cane varieties resistance to Red Rot. The work along these lines has been started as a Collaborative Project between the Division of Mycology and Plant Pathology of the Indian Agricultural Research Institute, New Delhi and the Sugarcane Breeding Institute, Coimbatore. Certain controlled crosses were affected with Resistant, Moderately Resistant and Susceptible varieties and the progenies assessed for their Red Rot resistance. These preliminary studies on the inheritance of Red Rot resistance have shown an indiscriminate distribution of resistance or susceptibility among all the progenies. Even a Suspectible × Susceptible cross has given some Resistant seedlings and *vice versa*. Similar results were obtained with the varieties derived from Resistant or Susceptible Pistil Parent; thus obviously indicating that the only way to evolve Red Rot resistant varieties is the careful screening of the seedlings and the cane varieties and selecting only those which show a fair degree of resistance. It is of utmost importance that if the hazards of Red Rot to the Sugar Industry are to be averted satisfactorily, great care must be exercised in recommending and releasing sugarcane varieties and encouraging cultivation of those that are fairly resistant to Red Rot.

Standards for Seedling Selections

Once a cross is completed and the fertilised fluff is obtained, utmost care should be exercised in making the selections. The promising seedlings which attain set standards of performance should be tested for resistance to major diseases. For Red Rot, it is essential that the resistance is tested both by the standard Plug Method as also for Nodal infection. Since it is known that the environment does influence the development of the disease, tests conducted only for the one season in one place would never be sufficient. A promising variety should, therefore, be tested for at least three seasons. The verdict on its behaviour would be far more reliable if the tests are conducted in different cane tracts of the country simultaneously. It would thus be possible to know the response of a variety under different climatic and possibly cultural conditions within a limited period of time.

The question of the fungus to be employed for varietal resistance trials also deserves due consideration. It is essential that we should use the most virulent strain of the Red Rot fungus available for the purpose. The strain which we are using at the Indian Agricultural Research Institute and Sub-station is probably now the most virulent among those pathogenically stable, available at present. But there is every possibility that a strain more virulent than what we have used at present may be produced in nature and thereby render our resistant varieties of the day susceptible. The best way, therefore, is to make an effort to keep a step ahead of nature by trying to release a variety resistant to the strain which is likely to be wide-spread in the near future. *Large scale, well-planned surveys would have to be, therefore, conducted in order to find out the possible changes in the dominant* C. falcatum *flora in the near future in the different cane tracts.* Apart from the most virulent strains which we have in our stock, the varietal trials would have to be made with those which are gradually assuming predominance in nature, as well. *The effort will not only yield varieties for tomorrow but also provide relevant data usable for forecasting service, which would probably be the first of its kind for Red Rot.*

Basis of Varietal Resistance

Testing of varieties for their behaviour towards Red Rot is a long and laborious job and takes a fairly long time apart from sufficient manpower to conduct the experiment and collect data at regular intervals. One would naturally ask if there could be any way of reducing this long period and get the desired information more quickly. This is an important line of work which should be taken up for investigation. The work in progress at the Indian Agricultural Research Institute has given some indications that there possibly is a relationship between the continuity of vacsular bundles through the nodes of a cane stalk and Red Rot resistance. From these studies it appears that the nodal region is the most important part of the cane stalk which determines the resistance of a cane variety to Red Rot and its progress within the stalk. There seems to be a direct correlation between the extent of continuity of vascular bundles in a stalk and its degree of susceptibility to Red Rot.

It has also been observed that certain gummy substances are formed in a stalk as a result of Red Rot infection. Although these gum-like substances have been found to be formed both in the resistant as well as susceptible cane varieties there appears to be a quantitative difference between the two. Varietal-ratings on the basis of the presence of gums or continuity of vascular bundles, or any other morphological character, would most certainly save a lot of time, provided some definite correlations could be established

for Red Rot resistance. Similarly, any morphological or physiological characters of the isolates which could give an indication of their virulence would be greatly welcome and would save the time and labour of determining the virulence by actual inoculations of canes, as is being done at present.

These lines of work, however, still require a great deal of further investigation. Work in this respect is in progress at the Indian Agricultural Research Institute.

Breeding of varieties, testing them against all virulent strains of Red Rot, multiplying the resistant stocks for distribution would of course give very useful results in due course but it is necessarily a very long range project. What we require at present is some quick solution to lessen, if not completely eradicate, the intensity of Red Rot infection, immediately in the badly-affected cane tracts. Use of disease-free seed would be a very helpful step in that direction and has been rightly emphasised from Butler's time. It has been repeatedly observed that a crop raised from disease-free setts has always fared better as compared to those which were produced from diseased seed-cane, as Red Rot is a cumulative disease. The diffiuclty in following this programme lies in the selection of Red Rot-free seed material in view of the secondary (nodal) infection which is usually not very easy to detect, especially the incipient cases, by the examination of the cut ends of the setts selected for planting.

Seed Nurseries and Seed Certification

In order to ensure a supply of disease-free seed of Red Rot resistant cane varieties to every cane grower, a chain of seed nurseries will have to be established. These should be of suitable size to meet the seed requirement *in full* of their respective units and, if deemed necessary, may be located even at some distance to minimize the chances of secondary infection. A system of Seed Certification should eventually be enforced. In order to carry out this programme, nucleus seed of guaranteed purity and freedom from disease, of suitable varieties would have to be supplied to the Primary Seed Nurseries by the Regional Research Stations. Regular and frequent examination of the Nursery crop, by properly trained personnel, should form an essential item of this programme. These technicians would conduct thorough roguing of the clumps affected with any major disease. They will also undertake clipping of the leaves showing mid-rib lesions till a suitable spray schedule to liquidate this source of infection is worked out.

Such a programme could naturally be undertaken only with the help of the Government. A High Power Red Rot Committee has, therefore, been recently set up by the Indian Central Sugarcane Committee, at whose request the Mycological Sub-Committee held its deliberations at the Indian Agricultural Research Institute under the Chairmanship of Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, and have suggested suitable schedules (see Appendix) for immediate measures for the Anti-Red Rot campaign that is being envisaged to be launched soon in the badly affected areas of U.P., Bihar and Punjab.

For the effective control of Red Rot epidemic the banning of the cultivation of susceptible cane varieties in the *entire* cane tract, as well as, the ratooning of Red Rot affected crop in epidemic areas, is absolutely essential and may be achieved even through legislation, if necessary. Red Rot should, thus be fought on war footing and emergency measures should be undertaken. Sugarcane Research and Development Workers and the local Administrative Officers would have to pool their resources and concentrate their efforts to root out Red Rot which is a challenge to the Sugar Industry in the country.

I am sure that with the scientific talent available in the country and the willing help and cooperation of the Government, the Cane Development Departments, the Factory and the Cane Grower, we will not be beaten in this race with a tiny but potent micro-organism and shall not allow it to remain as a menace to healthy, disease-free production of sugarcane crop. I am sure that sugarcane workers in India would rise to the occasion and face this uphill task with cooperation, courage and determination and make Red Rot a thing of the past, one day.

APPENDIX

Operational Steps in the Campaign for controlling Red Rot in seriously affected areas

October:

(1) A rapid survey of the Unit to mark out all affected and suspected cane fields and arrange for their crushing as early as possible when the mills start. These fields should be ploughed up immediately after harvest and the stubbles and trash removed and burnt.

It is appreciated that this would involve very heavy work, but keeping in view the incidence, a number of men would have to be made available for the purpose with the help of the Cane Development Department, Sugar factories etc. The task, however, may not prove so heavy as, when once a field is suspected to be infected, it need not be surveyed any further because it shows that the crop is infected and has to go in for early crushing. A more rigorous examination and survey of that field would be essential which is apparently free from infection and is proposed to be retained for seed purposes.

When the survey has been completed it would be for the staff concerned to decide as to which area will be ready for first crushing. The area most affected will go in first. The gradation and priority would be laid down by the States concerned.

It is considered necessary that this work would be completed before the next planting season in each case.

(2) Marking out the Red Rot free fields, select the best available and reserve them for seed purposes at the rate of 15 to 20 acres for every 100 acres to be planted, depending on incidence and spread of infection in the locality.

November, December and January:

(3) Frequent inspection of the selected fields and rigorous rouging out of any suspected cases of Red Rot, as also Smut. (Removal of the *entire clumps* and not merely the individual affected shoots).

Any selected field in which the Red Rot incidence exceeds 0·1 per cent will be discarded. Further, it is intended to gradually replace the affected varieties with the more resistant ones, but as that would take time, as an immediate measure, this step has to be followed for seed plots.

January:

(4) Checking up of these seed-cane plots for definite freedom from Red Rot infection by randomised sampling of the crop for nodal infection. (100 canes per acre; not more than one cane from each clump; the canes, after examination, to be sent on to the mill for crushing). Sampling method to be ascertained from the Statistician.

February:

(5) Distribution of the seed-cane material from these selected plots to the cane growers through the mill or the Cane Cooperative Societies on " Purzi " basis. A track of the material supplied to be kept and the resulting crop watched for freedom from the primary type of Red Rot infection.

(6) Rigorous seed selection of seed-canes and setts to be planted. Fungicidal seed-dressing of setts with Aretan (in-and-out dip) or Agallol for general protection of setts against soil micro-organisms and for quicker and better germination and higher yields (Gamma BHC-Aretan treatment where termite trouble is expected).

(7) Freeing from Red Rot infection of the fields to be planted to cane by carefully removing all trash and cane stubbles of the previous crop left in the field after harvesting and following longer rotation, and abandoning October planting in seriously-affected fields.

March-June:

(8) Periodic pre-monsoon inspection of the new crop and removal of affected clumps and their destruction. (*Entire clumps* and not merely the affected shoots to be removed).

July-August:

(9) Protection against rain-water or irrigation-water reaching the *seed-crop* after flowing through neighbouring Red Rot affected fields by constructing suitable bunds and channels in and around the fields. Efforts will be made to clip off and destroy the leaves showing mid-rib lesions.

September-October:

(10) Periodic post-monsoon inspection of the crop and removal of affected clump (*entire clumps*) from the fields as early as possible and their destruction. In the event of heavy Red Rot infection, cutting and crushing of the crop as early as possible to avoid further spread of the disease, as also ploughing-up of the fields and removal and destruction of stubbles and trash and all dried-up canes left in the field at the time of harvest.

There should be strict control against the use of seed cane material from Red Rot affected fields.

(11) Banning of cultivation of cane varieties known to be highly susceptible to Red Rot in the areas.

(12) Banning of ratoons in the area.

(13) Replacement of the affected varieties in the area as quickly as possible with such cane varieties as are fairly resistant to Red Rot, even though these may be slightly inferior in yield performance.

(14) Seed Nurseries to ensure supply of disease-free seed of Red Rot resistant cane varieties to every cane grower. Seed nurseries to be established on suitable sites and if necessary even at some distance to minimize chances of secondary infection.

A system of Seed Certification to be enforced eventually.

Nucleus seed of Guaranteed Purity and Freedom from disease of suitable varieties to be supplied for Primary Seed Nurseries from the Regional Research Stations.

Regular and frequent examination of the Seed Nursery crop by properly-trained personnel and rigorous roguing-out of the clumps affected with any major diseases; as also clipping-off the leaves showing mid-rib lesions till a suitable spray schedule to liquidate this source of infection has been worked out.

Cane varieties considered to be resistant to Red Rot by the Central and State Sugarcane Research Stations and the Indian Agricultural Research Institute as a result of their Varietal Resistance Tests, should be tried in observation plots in badly-affected areas for their Field Resistance to the disease.

Information regarding the Varietal Census in the affected areas and their Red Rot incidence should be incidentally collected and passed on to the Regional Research Stations as also diseased leaves and cane stalks for keeping a check on the occurrence of any new, virulent strain of the Red Rot fungus.

It is strongly felt that it would be necessary to carry out the programme as recommended in full, as every step suggested is important from the point of elimination of the diseases.

Miscellany

MEASURES AGAINST RED ROT

A THREE-YEAR scheme for controlling and eradicating the Red Rot disease a serious menace to 60,000 acres of sugarcane crop in border areas of eastern U.P. and north Bihar has been approved by the Government of India.

The work under the scheme is expected to start in October, and it is proposed to cover 30,000 acres of sugarcane crop in the two States in 1957-58.

Before the actual operations for rooting out this disease are undertaken, a survey of the seriously affected areas will be conducted and the incidence of the epidemic assessed.

The control measures will include early crushing of the affected crops, replacement of susceptible varieties, and eradication of the diseased clumps. Some useful cultural practices, such as proper rotation and stoppage of ratooning of diseased crops, will also be popularized.

The cost of the scheme is estimated at Rupees two lakhs, which will be made available to the two States by the Indian Central Sugarcane Committee of the Ministry of Food and Agriculture.

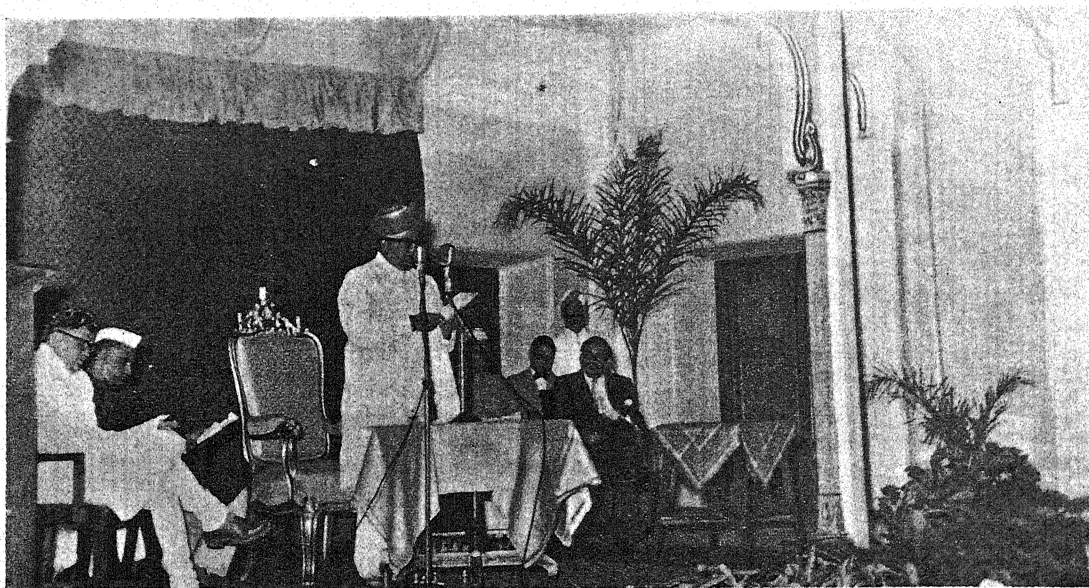
* * * * * *

INDIAN CENTRAL SUGARCANE COMMITTEE MEETING

THE 24th Meeting of the Indian Central Sugarcane Committee was held at Mysore on the 2nd December, 1957. The Main meeting of the Committee was preceded by the meetings of its various expert Sub-Committees and was inaugurated by His Highness Maharaja Sri Jaya Chamraja Wadiyar, Governor of Mysore, on Monday, the 2nd December, 1957. The Union Deputy Minister for Agriculture, Shri M. V. Krishnappa and the Minister for Agriculture, Mysore, Shri H. S. Rudrappa were also present.

In his inaugural speech, the Governor of Mysore stressed that the stabilisation of sugar prices was imperative. He added that the present food situation in the country made it very necessary to consider the question of augmenting sugarcane production in a re-orientated way so that the yield per acre could be increased, resulting in a higher crop, without encroaching on the acreage under food crops. This called for improved technique and the use of chemical fertilisers, whose effectiveness had been tested in research laboratories. The Governor pointed out that about 20 million agriculturists and workers were dependent on the sugar industry in India, which was second only to the textile industry in importance. The Governor also urged the Committee to suggest ways and means of raising the yield of sugarcane per acre in Mysore, at least to the level obtaining in the neighbouring States. He remarked that Mysore State after the reorganisation of States had emerged as one of the very important sugarcane growing States in the country with a total area of nearly 1·25 lakh acres under sugarcane. This was expected to rise to 1·60 lakh acres with the completion of the irrigation schemes now under execution.

Shri M. V. Krishnappa, Union Deputy Minister for Agriculture, welcoming the Governor and the members of the Indian Central Sugarcane Committee, reminded them that sugarcane was one of the most important commercial crops of India and had come to occupy a unique position in the country. The prosperity of millions of our cultivators, besides the manufacturers and sugarcane factory workers depended upon it. Sugar had also become a valuable foreign exchange earner to the tune of several crores after the country's own demands for this commodity had been fully met. He further stated that taking into consideration the achievements made in respect of sugar and sugarcane production in the First Plan and the requirements of sugar during the next five year period, targets of 22·5 lakh tons of sugar production and 780 lakh tons of sugarcane have been fixed under the Second Five Year Plan. The production in 1956-57 had already exceeded 20 lakh tons. It was hoped that these targets would be achieved if the whole area under sugarcane in the country is brought under intensive development with greater emphasis on essential items of development like irrigation facilities, adequate supply of manures and fertilisers, supply of seed of improved varieties, cane protection against pests and diseases and proper road development in sugar factory areas. He further stated that the results obtained in the areas where sugarcane development schemes were in operation had clearly indicated the potentialities of future achievements. The research work done at the various sugarcane research stations had given suitable varieties, suitable manurial and cultural schedules and necessary preventive and control measures against pests and diseases. The development and extension schemes should bring about the adoption of these schedules over the entire sugarcane area in all the States.



His Highness Maharaja Sri Jaya Chamraja Wadiyar, Governor of Mysore, inaugurating the 24th meeting of the Indian Central Sugarcane Committee. Shri M. V. Krishnappa, Union Deputy Minister for Agriculture, Shri H. S. Rudrappa, Mysore Minister for Agriculture, and Shri T. C. Puri, Joint Secretary, Ministry of Food and Agriculture, are also seen in the picture.

He also laid emphasis on intensive methods of cultivation and the introduction of varieties with high sucrose content. Improved acre yields should also lead to high production of sugar per acre; otherwise it might prove fallacious to say that increased production of cane was tantamount to increased production of sugar. He urged all sugarcane workers to look into the development schemes in this perspective, rather than aim only at increasing the tonnage of sugarcane per acre.

Shri T. C. Puri, Joint Secretary, Ministry of Food and Agriculture and President, Indian Central Sugarcane Committee, presided over the meeting.

The Committee sanctioned the Sugarcane Research Scheme, Mysore, with a Research Station at Mandya, Sub-stations at Hebbal and Babbur and Zonal Centres at Bidar and Gangawati. Besides other proposals, the Committee also sanctioned development plans to meet the needs of the Sugarcane Industry in Mysore State. The Committee recommended that the mechanical control measures against sugarcane borers which had proved effective in large-scale trials in the Punjab should be taken up by all the States wherever necessary for control of borers, as a part of their sugarcane development schemes.

Problems facing the *gur* industry were also discussed and the Committee recommended that trials regarding bulk storage of *gur* under local conditions should form part of the State Schemes for *gur* research, and the Indian Institute of Sugarcane Research, Lucknow in consultation with the National Warehousing Corporation, should chalk out a scheme for research in bulk storage of *gur*.

Through the kind courtesy of the Director, the venue of the meeting was the Conference Hall of the Central Food Technological Research Institute, Mysore.

Book Review

The Indian Sugar Industry (1955-56 Annual). Editor: M.P. Gandhi; Published by M.P. Gandhi & Co., Jan Mansion, Sir Pherozshah Mehta Road, Fort, Bombay-1; pp. 344; Price Rs. 6.00; by V.P.P. Rs. 7.00.

The latest edition of the Indian Sugar Industry Annual, as usual, provides a bird's-eye view of the Sugar Industry in the country. The statistical section arranged in 150 tables furnishes figures relating to practically every aspect of this important industry. It is a compendium of information including the distribution and capacity of factories, acreage under sugarcane, average annual wholesale prices of sugar, value of sugar exports from India; world sugar crop figures, etc. Othcr sections of the book include varied information i.e. legislation enacted in 1956, relating to the sugar industry in particular and industry in general, an account of sugarcane research and development work done in U.P., Bihar and the Sugarcane Breeding Institute, Coimbatore. Besides, other subjects as sugar and sugarcane production, prices of sugar, *gur*, *khandsari* and cane by-products, export and import position, sugar consumption—all provide useful information. Finally, there is a survey of the world sugar situation.

Indian Journal of Sugarcane Research and Development,

Vol. II, Pt. 1, (October-December., 1957).

Addendum

Studies in Saccharum spontaneum—The Geographical Distribution of spikelet length (pages 1-8):

Since writing the above, a specimen collected from Basrah (Iraq) came to flower. Its mean spikelet length is 4·50 mm. but it agrees with the Turkmenistan form in having the lower glume with a bidentate apex and the upper glume longer than the lower. It may be mentioned here that one of the forms from West Pakistan has recorded a spikelet length of 4·42 mm. and its upper glume is also longer than the lower. In gross morphology, the Iraqi form agrees with the West Pakistan and the Turkmenistan forms.

Corrigenda

Page	*Para*	*Line*	
1	1	2	*for* spicelets *read* spikelets
	3	4	*for* variant (*at the beginning of the line*) *read* variants
5	7	5	*for* exerted *read* exserted.
	9	6	*for* peninsula *read* peninsular
6	–	–	*Table III*: *for standard deviation of the Philippines, Fiji & New Guinea group read* 0·15 *instead of* 0·51
6	3	4	*after* Table IV *read* (page 7)
8	–	–	*Table IV:—Read column 4* "Mean spikelet length (mms)" *under* "Parents"
8	*Item No. 3 of summary:*		*for* chromosomes *read* chromosome.

Aerial Spraying of Insecticide against Cane Borers (page 57):

The Government of India procured two Beaver aeroplanes from Canada under the Colombo Plan for pest control and the training of Indian pilots. On the request of the West Bengal Government, one of the Beaver aeroplanes was acquired from the Directorate of Plant Protection, Quarantine and Storage for spraying the sugarcane crop from the air so as to supplement the ground spraying unit. The charges for the plane were Rs. 2,915/- for the first 100 acres and Rs. 2·65 for subsequent one acre.

Work was started on the 19th May, 1957 and the total area covered by the aerial spraying was 1,502 acres. On an average about 100 acres can be sprayed in one flying hour. The tank capacity of the plant is 192 gallons, but generally about 100 to 150 gallons of insecticide are carried for each trip of spraying. The plane, at the time of spraying, has to fly about six to ten feet high over the crop.

The insecticide used was endrex-20.—*Issued by the Directorate of Plant Protection, Quarantine and Storage.*

A NEW LEAF DISEASE OF SUGARCANE IN U. P.

By

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INTRODUCTION

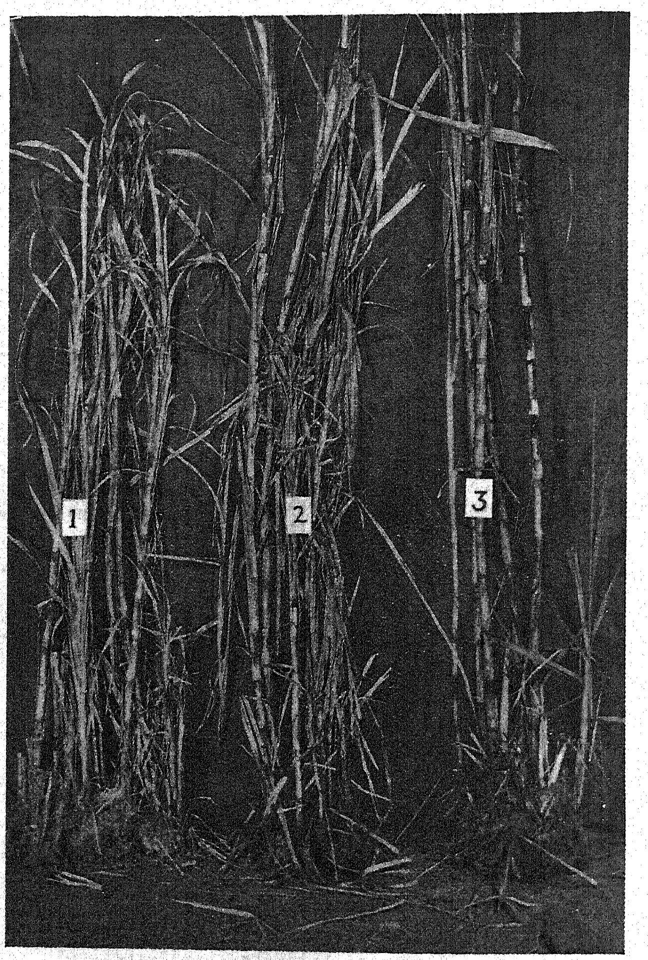
SINCE June 1955, a new disease of sugarcane suspected to be caused by virus has been observed in western U.P. During the dry hot weather, the disease is observed in a low intensity but after the rains it increases rapidly. A number of varieties have been found to be affected by the disease which seems to be increasing in proportions. Co.S. 245 has been affected the most.

SYMPTOMS

The symptoms of the disease are visible when the plants are 1 ft. to 2 ft. high. In which the younger leaves of the spindle are the first to be affected. The affected younger leaves are completely devoid of chlorophyll. The older leaves have long, narrow, whitish to pale longitudinal streaks alternating with streaks in which chlorophyll is present. The streaks are straight, regular and follow the course of vascular bundles. The older streaks become broader and their outline loses sharpness. In acute cases, the cane formation is seriously interfered with and the whole stool is converted into a bushy tuft of leaves without any stem formation. The severely-affected clumps dry up completely by December. In cases of milder infection a few canes may be formed, but the growth remains stunted and other shoots fail to develop into millable canes. The buds of the entire affected cane have a tendency towards premature sprouting giving out pale-coloured leaves and leaf sheaths. The sprouting of buds is much similar to the 'Spike' disease of sugarcane (1947). The sprout from the affected bud tends to make an acute angle with the stem (Fig.1).

FIG. 1. Showing severely affected clump of Co.S. 245. The sprout makes an acute angle with the cane.

The buds of the lower portion of the affected stem get enlarged in size while those of apical portion become papery. The diseased canes besides being stunted are lighter and narrow in girth and the germination capacity of the buds is very much reduced (Fig. 2, a, b and c). The symptoms of the disease have been noticed in the leaves of tillers developing towards the end of the season in apparently healthy normal clumps.



a b c

FIG. 2

a. Showing severely affected clump of Co.S. 245. The canes are lighter, shorter and narrow in girth.
b. Showing partially affected clump of Co.S. 245. Few normal canes are formed.
c. Showing healthy clump of Co.S. 245.

The disease is different from the 'Grassy shoot' or 'Bunchy top' (1955 and 1956) and the 'Leafy tuft' disease, a name recently given by Sharma (1957) to these diseases. The clumps affected by this disease, of course, develop into a bushy growth due to emergence of lateral buds but a few canes with smaller internodes and reduced girth do develop. There is no shortening of leaves at any stage. In view of the fact that the affected plants have leaves devoid of chlorophyll, it is proposed to call it 'Albino' disease of sugarcane.

OBSERVATIONS

Observations taken in experiments with different cultural and manurial treatments clearly indicate that there is no correlation between these treatments and the intensity of the disease. Organic or inorganic manures given at different periods of sugarcane growth in single or multiple doses of different intervals do not

have any effect on the intensity of the disease. Similarly, the cultural practices generally adopted by the progressive growers in the western districts of Uttar Pradesh i.e. differences in number of irrigation and intercultural operations do not have any bearing on the resistance of the host to the disease. Significant observations have been made on varietal behaviour towards the disease. The resistance of different varieties to this disease in different parts of the season is given in Table I.

TABLE I

Observations on the incidence of 'Albino' disease on different varieties of sugarcane

Sl. No.	Varieties	PERCENTAGE INCIDENCE ON			
		4-6-56	9-7-56	14-9-56	11-2-57
1.	Co. 851 ..	0·0	0·0	0·0	0·9
2.	Co. 951 ..	0·0	0·2	0·6	2·6
3.	Co. 957 ..	0·0	0·3	1·9	6·0
4.	Co. 969 ..	0·0	3·9	4·9	5·3
5.	Co. 975 ..	0·0	1·8	2·6	4·1
6.	Co. 994 ..	0·0	1·9	10·5	14·9
7.	Co.S. 514 ..	1·5	12·4	14·4	16·7
8.	Co.S. 515 ..	0·0	5·0	9·5	16·7
9.	Co.S. 519 ..	0·7	10·3	15 6	15·4
10.	Co.S. 532 ..	0·0	0·3	3·0	3·9
11.	Co.S. 536 ..	0·6	9·9	21·4	25·3
12.	Co.S. 546 ..	0·0	0·5	2·5	4·9
13.	Co.S. 548 ..	0·6	6·9	7·4	8·6
14.	Co. 312 ..	0·0	0·4	0·7	1·2
15.	Co.S. 245 ..	2·2	23·8	25·4	26·5
16.	Co.S. 321 ..	0·3	1·1	4·7	5·3

Note: The first observation was taken before rains; the second, after heavy showers; the third, during the rains and the fourth before harvest.

In an experiment conducted to study the effect of burning the trash *in situ* after harvesting the plant crop on its ratoon, periodical observations were recorded for intensity of the disease. The observations were confined to one of the susceptible varieties i.e. Co.S. 245 on y. The observations are summarised in Table II.

TABLE II

Incidence of 'Albino' disease in ratoon of Co.S. 245

Replication	TRASH BURNT			TRASH NOT BURNT		
	Total no. of stools	No. of diseased stools	Percentage infection	Total no. of stools	No. of diseased stools	Percentage infection
I	833	101	11·6	692	85	12·3
II	827	123	14·7	884	91	10·3
III	744	80	10·7	779	76	9·8
IV	724	93	11·4	729	80	10·9

Average incidence: 12·1 and 10·8 per cent respectively.

It is apparent from the above data that the cultural practices normally tending to reduce the incidence of diseases and pests in sugarcane fields, do not have any effect on the intensity of this disease. Burning of trash *in situ* has not mitigated the infection. It may be due to the infection hibernating in the root system or underground portion of the stubbles.

Damage.

In survey tours, it has been observed that the disease is on the increase. It was not uncommon to find ratoon crops of Co.S. 245 completely devastated by the disease in some fields of the western districts. In infected localities 5 to 15 per cent incidence was very common. Two to five per cent infection was also noticed on Co. 957, Co. 758, Co.S. 477 and Co.S. 515 in Muzaffarnagar and Meerut districts. Its destructive capacity is not fully realised at present, but if its unabated spread is allowed, some of the most important varieties like Co.S. 245, may be thrown out of cultivation on account of their susceptibility to the disease. No definite data regarding the actual loss of the cane crop due to similar diseases seem to be available. The authors have tried to assess the losses caused by the disease both in yield and juice quality. The results are given in Tables III and IV.

Table III

Loss in yield due to 'Albino' incidence

Sl. No.	Variety	Healthy canes			Apparently healthy canes in diseased stool			Diseased canes		
		Average weight of ten canes in lbs.	Average height in cms.	Average girth in cms.	Average weight of ten canes in lbs.	Average height in cms.	Average girth in cms.	Average weight of ten canes in lbs.	Average height in cms.	Average girth in cms.
1.	Co.S. 515	14·6	222·5	8·2	12·0	178·5	8·1	5·1	124·9	5·8
2.	Co.S. 245	20·6	223·5	8·8	20·0	209·5	8·0	12·0	144·6	7·9
3.	Co.S. 321	16·1	202·2	7·2	15·7	183·0	6·1	6·8	141·1	6·2
4.	Co.S. 536	15·7	191·0	7·2	11·7	153·1	6·7	3·7	126·8	5·8
5.	Co.S. 519	8·1	148·8	6·5	6·0	110·1	5·8	2·6	107·4	5·3
6.	Co.S. 514	13·4	183·4	7·3	12·1	152·9	6·0	5·0	109·7	4·5
7.	S. 49/53	13·0	194·9	6·5	11·1	173·5	5·9	4·3	123·9	4·6

Table IV

Loss in juice quality due to 'Albino' incidence

Sl. No.	Variety	Healthy cane				Apparently healthy canes in diseased stool				Diseased cane			
		Brix corrected	Pol.	Purity per cent	Sucrose per cent	Brix corrected	Pol.	Purity per cent	Sucrose per cent	Brix corrected	Pol.	Purity per cent	Sucrose per cent
1.	Co.S. 515	20·7	77·8	90·2	18·67	18·7	70·3	90·0	17·01	16·4	50·7	75·4	12·37
2.	Co.S. 245	20·4	79·2	93·1	19·01	20·4	78·3	92·1	18·79	12·1	35·8	73·4	8·89
3.	Co.S. 321	19·7	76·5	93·9	18·44	19·4	73·3	91·0	17·66	16·5	59·1	87·3	14·41
4.	Co.S. 536	20·7	75·5	87·5	18·12	19·7	71·1	87·1	17·13	18·7	67·5	87·4	16·33
5.	Co.S. 519	20·9	82·0	93·9	19·64	20·7	79·2	91·8	19·01	20·1	75·8	90·6	18·23
6.	Co.S. 514	21·0	75·2	85·7	18·01	20·5	70·7	82·6	16·97	17·7	60·2	82·6	15·12
7.	S. 49/53	20·8	78·3	90·1	18·75	20·0	75·5	90·8	18·16	16·9	60·6	85·6	14·61

Both the yield and juice quality are considerably affected. The adverse effect of the disease is not confined to the diseased canes only, but the apparently healthy canes of the disease stools also show signs of deterioration.

Experimentation

The disease is suspected to be caused by virus. In order to test its pathogenecity, apparently healthy canes were infected by inoculating the canes at the spindle with the juice extracted from the diseased leaves. The infection was provided by the same method as was employed by Luthra (1935) in his experiments on mosaic disease of sugarcane. In another set of plants, infection was provided to the stem with the juice prepared from the affected plants by the plug method. In some cases the pith from affected plants was inserted in the healthy plants. These experiments were done in young tillers as well as mature canes. Observations were made from time to time to see whether the inoculated plants were showing any sign of infection. It was observed that all the types of inoculations failed to produce any symptom of infection.

Summary

A new leaf disease (ALBINO) of sugarcane suspected to be caused by virus was observed for the first time in western U.P. The characteristic symptoms of the disease appear on the plants before the rains but it assumes serious proportions during rains.

The disease causes long, narrow, whitish to pale yellow longitudinal streaks devoid of chlorophyll on the leaves. The cane formation is interfered with and the whole stool is converted into bushy tuft. The diseased canes besides being stunted are lighter and narrow in girth. The buds have a tendency towards premature sprouting.

It has been observed that there is no correlation between cultural practices tending to reduce other cane diseases and incidence of albino disease. Sugarcane varieties show marked differences in their susceptibility to the diseases. The disease is most serious on Co.S. 245 but infection is also noticed on Co. 957, Co. 758, Co.S. 477 and Co.S. 515.

The disease causes appreciable losses in the weight of cane and adversely affects the juice quality.

The pathogenecity of the virus could not be established and no infection was produced by inoculations.

Acknowledgments

The authors are thankful to Dr. R. K. Tandon, Director, Sugarcane Research for going through the manuscript and for helpful suggestions. Thanks are also due to the Indian Central Sugarcane Committee which partly finances the scheme under which the work was conducted.

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INFLUENCE OF THE INCLINATION OF CANE STALKS ON THEIR JUICE QUALITY

By

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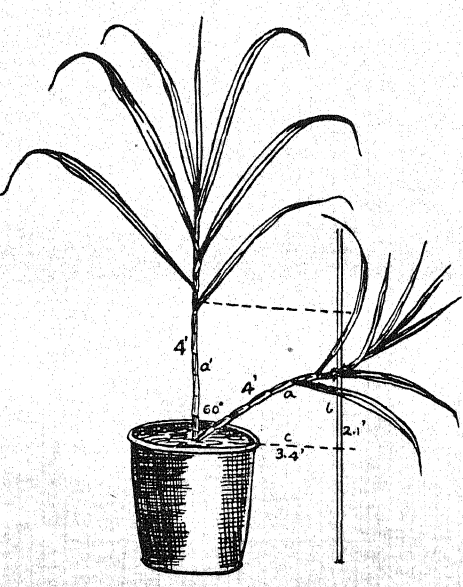
IT is well known that lodging of sugarcane influences appreciably sucrose content of cane juices. During the course of crop growth stalks might lodge to varying extents after they are well-grown. Cyclonic winds accompanied by heavy rainfall predispose a crop to severe lodging. Lodging of the sugarcane crop might be due either to the senescence of roots after the crop ages or due to breaking-up of the root system consequent on the development of cracks in the soil in summer months. Though it is realised that lodging adversely influences the quality of sugarcane juice, precise information on the subject is lacking and conclusious of a general nature alone could be drawn from the available data.

Parthasarthy and Rao (1953) reviewed the available results of experiments on the subject and reported for the first time that the degree of inclination of cane stalk appeared to be closely associated with the depression in juice quality. In order to find out the exact relation between the degree of inclination of lodged cane stalk and the extent of depression in juice quality a pot experiment was conducted at the Sugarcane Research Station, Anakapalle during 1954 and the results from the same are presented in this paper.

MATERIAL AND METHODS

Variety Co. 419 was used for experimentation in pots. Only one cane was allowed to develop; the rest of the shoots being removed as and when they emerged. In this investigation the cane stalk was assumed to be cylindrical and standing erect. A constant point on the stalk—the first transeverse mark—was taken as the upper limit of the stalk and attached to a bamboo scaffold at the age of eight months from planting. The height of the scaffold and its distance from the base of the cane stalk were adjusted in each treatment in order to bend the experimental cane to the exact inclination required. The method is illustrated diagrammatically for a 60° inclination in Fig. 1. Four inclinations, viz., 30°, 45°, 60°, and 75° from the



a = Length of cane 4′

c = Length of cane × sin ∅ 60′°
= 40′ × 0·86 = 3·4′

$a^2 = b^2 + c^2$

$b^2 = a^2 - c^2 = 16{\cdot}0 - 11{\cdot}56 = 4{\cdot}44$

$b = \sqrt{4{\cdot}44} = 2{\cdot}1'$

FIG. 1. Method adopted for bending cane to 60° from the vertical. The bamboo was fixed at a distance of 3·4′ from the base of the cane and the cane was tied at a height of 2·1′ on the bamboo.

vertical were chosen for comparative study with 0° inclination or the erect canes. Each treatment was replicated five times. Chemical analysis of juices was done 45 days after initiating the treatment. True sucrose in juice was estimated by the Jackson Gillis Clerget modification (Method IV). Reducing sugars were determined by Lane Eynon Volumetric method using methylene blue as internal indicator.

Experimental Results and Discussion

The true sucrose per cent in juice of the different treatments is furnished in Table I and the analysis of variance in Table II.

Table I

True sucrose per cent in juice of canes inclined to different degrees from vertical

Cane No.	Degree of inclination				
	0° (Erect)	30°	45°	60°	75°
1	11·57	8·32	9·75	9·01	7·80
2	10·92	9·73	8·92	8·51	5·25
3	10·25	9·31	9·62	11·50	6·41
4	9·04	10·71	7·93	7·36	5·48
5	10·75	11·68	9·61	7·05	5·95
Mean ..	10·51	9·94	9·16	8·68	6·18

Table II

Analysis of variance

Variation due to	D.F.	Sum of squares	Mean sq.	V_1/V_2	F. from tales P=0·01
Total	24	83·10	..	..	..
Between Classes	4	56·12	14·03	10·39	4·43
Linear regression	(1)	44·80	44·80	33·20	8·10
Quadratic regression ..	(1)	8·91	8·91	6·60	..
Deviations	(2)	2·41	1·20	..	..
Within classes	20	26·98	1·35	..	..

The differences were statistically significant and indicated the superiority of erect canes. The linear regression of sucrose on degree of inclination was very highly significant and accounted for a very large portion of variation. The quadratic term was significant only at five per cent level. The deviations were not significant. The results indicated that for practical purposes though a linear fit is sufficient to predict the loss of sucrose in juice due to lodging of cane, more than quadratic term is not required. The loss of sucrose in juice due to the inclination of cane stalk is illustrated in Fig. 2.

The true purity values of juices presented in Table III also showed a similar depressing effect, the lowest coefficient of purity being recorded from juices of canes bent to greater inclination.

Reducing sugars in juice were estimated simultaneously and are presented in Table IV and the relative analysis of variance is given in Table V.

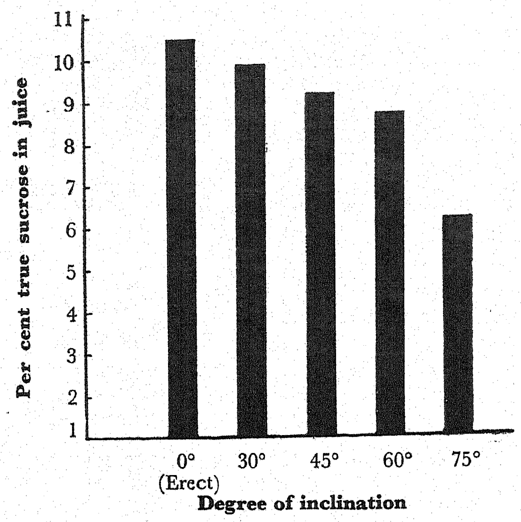


FIG. 2. Loss of sucrose per cent juice due to degree of inclination.

TABLE III

True purity coefficient of juices of canes inclined to different degrees

Cane No.	DEGREE OF INCLINATION				
	0° (Erect)	30°	45°	60°	75°
1	87·52	74·55	77·88	77·94	72·23
2	82·47	75·19	75·98	72·92	74·89
3	82·39	77·33	80·37	81·04	67·69
4	83·08	73·01	75·38	74·50	78·74
5	80·50	80·47	81·72	74·68	76·28
Mean ..	83·19	76·11	78·27	76·22	73·97

TABLE IV

Reducing sugars per cent juice of canes inclined to different degrees

Cane No.	DEGREE OF INCLINATION				
	0° (Erect)	30°	45°	60°	75°
1	0·469	0·716	0·783	0·751	1·185
2	0·378	0·979	1·125	0·876	0·920
3	0·294	1·068	0·857	0·868	1 057
4	0·415	1·138	0·986	0·897	0·774
5	0·389	0·698	0·695	0 882	0 958
Mean ..	0·389	0·919	0·889	0 855	0 979

TABLE V

Variation	D.F.	Sum of squares	Mean sq.	V_1/V_2	F. Tables $P/=0\cdot01$
Between classes ..	4	1·1300	0·2825	14·00	4·43
Within classes ..	20	0·4034	0·02017	..	..
Total	24	1·5334	..	..	..
Contrast between erect and inclined canes ..	1	1·0885	1·0885	..	..
Among inclined canes ..	3	0·0415	0·0138	Less than 1	Not significant
Error	20	0·4034	0·02017	..	..

Juice from erect canes contained lowest amount of reducing sugars. Like the sucrose content of juices reducing sugars did not show any definite trend with the degree of inclination of cane stalk, the mean reducing sugar content of these stalks being practically the same, irrespective of the inclination. This was also reflected in the analysis of variance shown at the foot of Table V, wherein practically all the variation was accounted for by the single contrast, erect versus inclined canes; the differences within the inclined canes being not significant. The results also suggested that the entire loss in sucrose due to bending of cane stalk was not accounted for by the increased accumulation of reducing sugars in juice.

SUMMARY AND CONCLUSIONS

Inclined canes were found to be inferior in juice quality to erect canes. They recorded less sucrose and more of reducing sugars in juice with a low coefficient of purity.

The depression in juice sucrose significantly increased with the degree of inclination of cane stalk from the vertical. The quadratic term, fitted the relation very well, though for practical purposes a linear fit seemed to be sufficient.

Accumulation of reducing sugars was found to be higher in juices of inclined canes, but no definite trend with the extent of inclination was discernible.

ACKNOWLEDGMENTS

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THE SOILS OF BAHERI ZONE OF BAREILLY DISTRICT (U.P.)

By

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With a view to studying the soil conditions, soil survey work was carried out in the Cane Development Zone of Kesar Sugar Works Ltd., Baheri, district Bareilly, U.P. The factory is situated in Baheri tehsil of Bareilly district on the Bareilly-Nainital Road at a distance of thirty miles from Bareilly. The district lies in the centre of Rohilkhand between 28·1° and 28·54° north latitude and 78·58° and 79·47° east longitude. The average annual rainfall of Baheri tehsil is fairly high being about 49 in. The high rainfall is naturally owing to the area being in close proximity to the Himalayan hills of Nainital district. The mean annual temperature of the district is 76·2°F.

Topography and soils: The zone is marked by a number of rivers and *nalas* which have a south-westerly direction. Contiguous to the Himalayan Tarai area is the *khadir* area with apparently level topography but gently sloping towards south west. The *khadir* soils are found between the various rivers and *nalas* and appear to have been formed by the alluvial deposits of these rivers which overflow during heavy rains.

Methods of Analysis and Survey

Soil profiles were studied *in situ,* up to 6 ft. from the surface or up to the ground water-table if above 6 ft. representing the different soil types of the zone. The morphological characteristics of these soils were further studied in the laboratory under uniform conditions. Soil samples passing a 2 mm. sieve were used for analysis. The analysis of hydrochloric acid extract was carried out by the method of A.E.A. (Wright, 1939); organic carbon by Walkleys method; total nitrogen by Kjeldahls Grooning Arnold method; carbon-dioxide by Schroetters apparatus; mechanical analysis by the international pipette method, exchangeable bases by the method of Williams, Sigmond and Iyengar; pH value by Macbeth pH meter; the soil-moisture relationship with the help of Keen-Raczkoweski boxes and moisture equivalent by Bouyoucos method.

The soil survey was carried out taking each village as unit. The whole area was thoroughly traversed and soil samples were obtained from profiles dug at representative sites.

Data and Discussion

On the basis of the topographical situations, morphological characteristics and the analytical data, the soils of Baheri cane development zone have been classified into three major types viz. Type I (soils of the flood-basin), Type IV (freely-drained soils of the old alluvial basin) and Type IV/II (soils of the old alluvial basin with restricted drainage). The most important characteristics of these soil types is the status of calcium carbonate present and their maturity. Calcium carbonate, in conjunction with topography and climatic conditions, has functioned most prominently in the genesis of these soils. In type I soils, calcium carbonate is present in a finely precipitated form throughout the profile and also in a nodulated form in the sub-soils. The Type IV soils are free from lime concretions; while in type IV/II soils there is a distinct layer of calcium carbonate concretions, generally forming a pan which restricts drainage. The depth and thickness of the *kankar* layer as well as the shape, size and quantity of nodules vary considerably. Water-logging conditions mostly prevail in Type IV/II soil type. Each of the above soil types has been further divided into textural sub-types, depending on the texture of the surface as well as sub-soil layers. They are Type I silty loam Type I silty clay loam, Type IV sandy loam, Type IV/II sandy loam and Type IV/II clay loam. The morphological characteristics and the analytical data of representative soil profiles are given in Tables I to VIII.

Most of the area of the central part of the zone is of Type I soils with a silty loam texture. This is an important cane-growing area. The colour of the surface soils is ashy-grey to brownish-grey which turns to dark grey on wetting. The soils, particularly the sub-soils, show signs of reduction of iron salts. Surface water-logging during the greater part of the rainy season is common. Calcium carbonate is found throughout the depth of the profile, being present in amorphous form.

TABLE I

Showing morphological characteristics of a Type I silty loam soil profile

Depth	Description
0″– 6″	Bluish-ashy grey, dark grey when wet; silty loam with a bluish tinge; cloddy; clods stable in water, few fine calcium carbonate nodules; effervescence with HCl; alkaline with B.T.B.
6″–20″	Yellowish-brown, dark grey when wet; silty loam; cloddy; clods friable; small dark concretions, bluish tinge; slight effervescence with HCl; alkaline with B.T.B.
20″–32″	Yellowish-grey, darkens when wet; sandy loam, structureless; mica particles; greenish-blue tinge; slight effervescence with HCl; alkaline with B.T.B.
32″–45″	Yellowish, brownish-yellow when wet; silty loam; many brown concretions and *kankar* nodules; effervescence with HCl; alkaline with B.T.B.
45″–60″	Yellowish, yellowish-brown when wet, silty loam; big *kankar* nodules, greenish-yellow cement; effervescence with HCl; alkaline with B.T.B.
60″–72″	Brownish-grey, dark grey when wet; sandy; micaceous, loose, many brown spots; effervescence with HCl; alkaline with B.T.B.

TABLE II

Showing morphological characteristics of a Type I silty clay loam soil profile

Depth	Description
0″– 6″	Ashy-grey; dark grey when wet, silty loam; cloddy; bluish tinge, very fine *kankar* nodules; effervescence with HCl; alkaline with B.T.B.
6″–17″	Yellowish-grey, dark grey when wet; silty clay loam; cloddy; brown mottlings and concretions; slaty tint; effervescence with HCl; alkaline with B.T.B.
17″–28″	Whitish-yellow, dark grey when wet; silty clay loam; cloddy; greenish slaty tint; many fine *kankar* nodules; effervescence with HCl; alkaline with B.T.B.
28″–40″	Brownish-yellow, dark grey when wet with a bluish tint; silty clay loam; iron concretions and *kankar* nodules; effervescence with HCl; alkaline with B.T.B.
40″–50″	Yellowish, brownish-grey when wet; silty loam; cloddy; greenish yellow cements, few iron concretions and very fine *kankar* nodules; effervescence with HCl; alkaline with B.T.B.
50″–62″	Brownish-yellow, more brown when wet, silty loam; micaceous, greenish yellow cements; big black concretions; effervescence with HCl; alkaline with B.T.B.

These soils are generally ashy-grey on the surface which turns to dark grey on wetting. Presence of calcium carbonate in amorphous as well as fine nodulated form constitute the most important characteristics of such soils. Mottled grey, yellowish and rusty colours indicate permanently saturated conditions of these soils and ths sub-soils appear to be in highly hydrated condition. The bluish and greenish tint indicate the reduction of iron salts.

TABLE III

Showing morphological characteristics of a Type IV sandy loam soil profile

Depth	Description
0″– 8″	Brownish to greyish-brown, dark grey when wet; sandy loam; cloddy to structureless; no effervescence with HCl; neutral with B.T.B.
8″–23″	Brownish, more brown when wet; sandy loam; dark brown concretions and nodules; no effervescence with HCl; neutral with B.T.B.
23″–41″	Yellowish-borwn, more brown when wet; sandy loam; no effervescence with HCl, neutral with B.T.B.
41″–72″	Brownish-yellow to greyish-yellow; brownish-grey when wet; sandy; no effervescence with HCl; neutral with B.T.B.

The surface layers are brownish in colour. Hydrated oxides of iron are common in the sub-soil while signs of reduction of iron salts are absent. The soils generally have coarse texture, presenting favourable conditions for leaching. Calcium carbonate concretions are absent. There is no tendency to restrict drainage.

TABLE IV

Showing morphological characteristics of a Type IV/II sandy loam soil profile

Depth	Description
0″– 7″	Brownish, more brown when wet; sandy loam; structureless to cloddy; clods unstable in water; brown mottling, no effervescence with HCl; neutral with B.T.B.
7″–23″	Brown, greyish-brown when wet; sandy loam; micaceous, loose and friable; no effervescence with HCl; neutral with B.T.B.
23″–52″	Brownish-yellow; more brown when wet; sandy; loose; micaceous; brown spots; no effervescence with HCl; neutral with B.T.B.
52″–60″	Brownish-yellow, yellowish-brown when wet; sandy loam; cloddy; few black concretions; sand pockets within the layer; no effervescence with HCl; slightly alkaline with B.T.B.
60″–64″	Greyish to greenish-yellow; more greenish when wet; sandy; loose and micaceous; moist, few calcium nodules; slight effervescence with HCl; alkaline with B.T.B.
64″–72″	Brownish-yellow, more brown when wet; sandy loam; cloddy to structureless; greenish tinge; many calcium and iron concretions forming a sort of pan; effervescence with HCl; alkaline with B.T.B.

The Type IV/II sandy loam soils differ from Type IV sandy loam soils in that the former are characterised by the presence of calcium carbonate accumulation in the last horizon, a remarkable feature of this soil type, which is absent in the latter. These soils have been mostly found in the depressions of the old alluvial basin and generally have a higher water-table.

TABLE V

Showing morphological characteristics of a Type IV/II silty clay loam soil profile

Depth	Description
0″– 7″	Yellowish-grey, silty clay loam; cloddy; few brown and black spots; no effervescence with HCl; neutral with B.T.B.
7″–15″	Greyish-yellow; silty clay loam; cloddy; few brown and black spots; no effervescence with HCl; neutral with B.T.B.
15″–28″	Dark grey; clay loam; cloddy; clods very hard; brown mottlings and few black smears; fine *kankar* nodules, effervescence with HCl; slightly alkaline with B.T.B.
28″–51″	Yellowish-grey; clayey; cloddy; brown spots and black smears; small *kankar* nodules; effervescence with HCl; alkaline with B.T.B.
51″–72″	Bluish-grey; clay loam; cloddy; clods very hard; cemented; black iron concretions and brown smears; pea sized *kankar* nodules throughout the layer; effervescence with HCl; alkaline with B.T.B.

These soils are also found in the depressions. The sub-soils are in an anaerobic condition, leading to the reduction of hydrated iron oxide. The soil grains are usually cemented. There is illuviation of clay and precipitation of iron oxides in the sub-soil. Presence of calcium carbonate nodules in the sub-soil is a remarkable feature of this type as well.

The analytical data of five representative soil profiles, viz., Type I silty loam, Type I silty clay loam, Type IV sandy loam, Type IV/II sandy loam and Type IV/II clay loam, which cover the greater part of the zone, are given in Table VI to VIII.

Type I: In both silty loam and silty clay loam profiles the percentage of coarse sand is very small. The soils are rich in silt content throughout. There is uneven distribution of clay in silty loam profile; on the other hand in silty clay loam profile there is illuviation of clay in the third horizon. Silt follows similar

trend. In silty loam profile there is illuviation of silt content in the fifth horizon. On the whole, both the profiles possess silty character.

TABLE VI

Mechanical composition of Types I, IV and IV/II soils (air-dry basis)

Soil type	Depth	Coarse sand per cent	Fine sand per cent	Silt per cent	Clay per cent
Type I silty loam	0″– 6″	0·41	43·64	29·10	18·65
	6″–20″	0·18	47·87	28·35	15·90
	20″–32″	0·37	52·61	30·92	12·45
	32″–45″	0·21	39·42	40·15	12·30
	45″–60″	0·18	12·90	62·38	18·68
	60″–72″	1·06	87·29	6·23	4·05
Type I silty clay loam	0″– 6″	1·85	46·88	32·02	15·00
	6″–17″	0·06	20·60	45·90	26·32
	17″–28″	0·24	3·20	51·82	37·12
	28″–40″	1·08	23·14	34·27	34·74
	40″–50″	1·37	43·24	28·65	22·65
	50″–62″	3·32	54·11	21·07	18·52
Type IV sandy loam	0″– 8″	13·09	57·19	14·20	13·30
	8″–23″	13·51	54·94	13·20	15·70
	23″–41″	12·20	61·80	10·80	12·00
	41″–72″	30·27	52·12	6·70	8·80
Type IV/II sandy loam	0″– 7″	4·75	53·55	23·10	12·82
	7″–23″	5·52	53·27	24·17	11·77
	23″–52″	28·84	50·28	3·87	8·02
	52″–60″	1·61	60·47	17·07	16·65
	60″–64″	13·44	64·28	10·50	4·80
	64″–72″	0·81	60·56	27·30	7·65
Type IV/II clay loam	0″– 7″	0·12	25·44	47·10	21·50
	7″–15″	0·18	31·42	42·20	20·70
	15″–28″	0·22	8·80	48·10	35·50
	28″–51″	0·60	5·80	45·20	39·30
	51″–72″	0·27	17·95	34·50	38·80

Type IV: The Type IV sandy loam soils (vide Table VI) contain more coarse sand than Type I soils, the maximum being in the last horizon. Silt fraction decreases with depth and there is little illuviation of clay in the second horizon. The fine sand and coarse sand fractions together constitute greater part of the soil. On account of higher fractions of coarse sand these soils are generally well-drained and water requirement is high.

Type IV/II: The IV/II sandy loam soils contain fairly high coarse sand fractions. Silt is unevenly distributed, the maximum being in the last horizon. Clay fraction is also usually low and unevenly distributed in the various horizons of the profile. The texture of the profile on the whole is sandy loam except the two sandy horizons i.e. third and the fifth. In Type IV/II clay loam profile the coarse sand fraction is very little. Silt content fluctuates within narrow limits in the first four horizons with slight decrease in the last. There is marked illuviation of clay in the last three horizons. The texture on the whole varies from silty clay loam on the surface to clayey in the lower depths. Because of the hard clayey sub-soil and presence of *kankar* pan, this type of soil is generally water-logged during rains.

The physical and physico-chemical analysis of the profiles are given in Table VII.

TABLE VII

Physical and physico-chemical analysis

(Air-dry basis)

Soil type	Depth	Water-holding capacity per cent	pH	Organic carbon per cent	Total nitrogen per cent	Total exchangeable bases m.e. per cent	Exchangeable calcium m.e. per cent
Type I silty loam	0″– 6″	53·39	7·6	1·83	0·156	16·72	6·80
	6″–20″	43·22	7·4	0·64	0·077	13·25	4·90
	20″–32″	43·24	7·4	0·39	0·043	11·71	3·91
	32″–45″	46·65	7·6	0·31	0·038	10·83	5·53
	45″–60″	50·18	7·6	0·39	0·033	11·44	4·00
	60″–72″	33·04	7·6	0·08	0·022	6·45	1·61
Type I silty clay loam	0″– 6″	45·73	7·6	0·80	0·076	6·75	2·00
	6″–17″	57·24	7·6	0·53	0·039	10·50	4·00
	17″–28″	64·63	7·6	0·56	0·047	11·00	4·50
	28″–40″	54·97	7·6	0·56	0·031	12·75	7·75
	40″–50″	45·67	7·6	0·25	0·031	12·54	8·00
	50″–62″	43·77	7·4	0·21	0·029	10·50	7·25
Type IV sandy loam	0″– 8″	33·04	7·1	0·50	0·042	8·5	7·0
	8″–23″	37·69	7·1	0·28	0·018	9·5	8·0
	23″–41″	36·24	7·0	0·20	0 028	10·0	7·5
	41″–72″	30·90	7·1	0·12	0·022	8·0	6·5
Type IV/II sandy loam	0″– 7″	39·27	7·0	0·52	0·051	9·40	6·29
	7″–23″	36·18	7·0	0·31	0·042	7·60	4·93
	23″–52″	29·49	7·0	0·16	0·014	8·81	3·06
	52″–60″	45·11	7·4	0·26	0·041	10·80	7·48
	60″–64″	31·15	7·5	0·13	0·031	10·00	7·82
	64″–72″	45·11	7·7	0·24	0·036	11·27	7·14
Type IV/II clay loam	0″– 7″	53·55	7·1	0·98	0·055	15·50	10·90
	7″–15″	52·90	7·1	0·59	0·053	17·50	13·00
	15″–28″	64·92	7·4	0·78	0·053	16·30	11·30
	28″–51″	64·79	7·5	0·58	0·088	21·20	13·70
	51″–72″	51·60	7·5	0·49	0·063	15·60	9·35

Type I: Water-holding capacity is maximum on the surface in silty loam profile, which seems to be due to high percentage of organic matter. The increase in water-holding capacity from third horizon to fifth horizon seems to be due to the presence of silt fraction in increasing quantities which in the presence of calcium carbonate might have acquired feeble colloidal properties. The pH values range from 7·4 to 7·6 organic carbon and total nitrogen contents are quite high in the first two horizons and then decrease with depth. The percentage of total exchangeable bases is fairly high but calcium saturation is somewhat low. In silty clay loam soils, water-holding capacity is high and increases with depth up to the third horizon and then decreases with depth which correlates with clay contents. Total base exchange status is remarkably low, considering the high content of clay fractions with low lime saturation. The surface layer is fairly rich in both organic matter and nitrogen which decrease with depth.

Type IV sandy loam: This soil type has the lowest water-holding capacity amongst the three types, because of its open and coarser texture. The pH values of soils are medium. Organic carbon and nitrogen are moderate at the surface owing to proper soil management and decrease with depth. Total exchangeable bases are low with adequate lime saturation and follow the trend of clay content.

Type IV/II: Sandy loam soils of this type have an average water-holding capacity. The soils are neutral on the top but show alkaline reaction in the sub-soil. The organic matter and nitrogen contents are average on the surface and vary according to clay content in the sub-soil. Total exchangeable base status is low, but the exchange complex is adequately saturated with calcium. Type IV/II clay loam soils have a good water-holding capacity. pH values are slightly alkaline ranging from 7·1 to 7·5. The soils are rich in organic matter and nitrogen contents owing to good manuring with organics. Total exchangeable base content is high with adequate lime saturation.

The analytical data of HCl extract of different soil types are given in Table VIII.

TABLE VIII

Analysis of HCl extract (percentage on air-dry basis)

Soil type	Depth	Moisture	Loss on Ignition	HCl Insols	R_2O_3	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	P_2O_5	CO_2
Type I silty loam	0″–6″	1·72	4·39	74·41	13·88	7·96	5·92	1·78	1·06	1·34	0·144	0·84
	6″–20″	1·22	2·56	72·67	17·89	12·13	6·76	0·97	0·44	1·37	0·132	0·60
	20″–32″	1·26	1·85	74·91	17·65	9·65	8·00	1·42	0·66	1·15	0·106	0·94
	32″–45″	1·00	2·75	73·12	16·32	10·40	5·92	2·26	0·61	0·89	0·055	1·05
	45″–60″	1·50	3·46	65·91	21·27	13·06	8·21	2·86	1·37	1·36	0·073	1·26
	60″–72″	0·30	1·21	85·51	9·82	5·02	4·80	1·06	0·88	0·69	0·040	0·36
Type I silty clay loam	0″–6″	0·27	3·19	78·46	13·33	8·37	4·96	1·61	0·67	0·49	0·249	0·37
	6″–17″	0·40	4·03	69·30	19·49	12·09	7·40	2·65	1·18	0·73	0·252	1·18
	17″–28″	0·48	4·40	61·08	28·51	18·75	9·76	2·07	1·16	1·18	0·252	0·67
	28″–40″	0·53	3·91	69·85	20·99	14·23	6·76	0·85	0·91	1·23	0·208	0·13
	40″–50″	0·48	2·88	78·10	15·29	9·45	5·84	0·87	0·62	0·68	0·221	0·26
	50″–62″	0·32	2·69	80·75	13·47	8·31	5·16	0·74	0·71	0·50	0·229	0·13
Type IV sandy loam	0″–8″	0·25	2·68	87·74	7·79	4·55	3·24	0·46	0·18	0·59	0·086	..
	8″–23″	0·33	2·65	85·19	9·96	5·96	4·00	0·46	0·18	0·59	0·086	..
	23″–41″	0·29	2·68	84·17	10·82	6·46	4·36	0·53	0·15	0·67	0·093	..
	41″–72″	0·14	2·28	84·90	10·35	6·15	4·20	0·53	0·15	0·38	0·060	..

TABLE VIII—(*Concld.*)

Soil type	Depth	Moisture	Loss on Ignition	HCl Insols	R_2O_3	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	P_2O_5	CO_2
Type IV/II sandy loam	0″– 7″	0·96	2·31	84·37	9·70	5·82	3·88	0·63	0·53	0·60	0·083	..
	7″–23″	0·78	2·18	83·29	10·50	6·42	4·08	0·57	0·37	0·81	0·117	..
	23″–52″	0·26	1·66	87·12	8·86	5·43	3·43	0·60	0·50	0·42	0·089	..
	52″–60″	0·67	2·19	81·27	12·70	7·84	4·86	0·79	0·78	0·74	0·105	..
	60″–64″	0·23	1·87	85·28	10·20	6·59	3·60	0·83	0·76	0·65	0·117	..
	64″–72″	0·48	2·62	77·21	14·21	9·31	4·90	2·02	0·97	0·86	0·130	1·23
Type IV/II clay loam	0″– 7″	1·48	4·27	71·90	19·24	12·62	6·60	0·90	0·36	1·49	0·207	..
	7″–15″	1·09	3·56	73·45	18·48	12·23	6·26	0·78	0·30	1·10	1·256	..
	15″–28″	1·90	5·05	63·68	25·97	18·29	7·68	1·22	0·33	1·96	0·219	0·95
	28″–51″	2·30	5·17	58·96	28·24	19·81	8·43	1·39	0·37	2·17	0·157	0·93
	51″–72″	1·68	4·81	64·96	25·35	17·60	7·75	1·19	0·30	1·55	0·200	0·16

Type I: The analytical data for silty loam soils show that there is illuviation of sesquioxides in the fifth horizon and follow the trend of silt plus clay. The soils are rich in calcium to the extent of being mildly calcareous throughout the profile. There is evidence of illuviation in the fourth and fifth horizons. Magnesium is throughout less than calcium; water-soluble salts concentration is normal. Potash and phosphate seem to be adequate. Type I silty clay loam soils are fairly rich in sesquioxides which follow the trend of clay. The soils are calcareous throughout the profile with a moderately high calcium status in the top horizons. Magnesium is less than clacium throughout the profile. The soils are rich in organic matter, potash and phosphates with a moderate nitrogen status. The concentration of soluble salts is moderately high on the surface which decreases sharply with depth. The concentration of soluble salts on the surface may be owing to high water table and evaporation of soil-water brought to the surface through capillary potential.

Type IV: HCl insolubles are high at the surface and decrease with depth. Sesquioxides on the other hand follow a reverse trend. There is illuviation in the third and fourth horizons. Iron and alumina follow the trend of sesquioxides. Lime content is very low. Magnesium is less than lime throughout the profile. Potash and phosphate contents are average and more or less evenly distributed. The concentration of soluble salts is low. These are mature soils.

Type IV/II: The illuviation of sesquioxides to the last horizon in Type IV/II sandy loam soils is prominent. Both iron and alumina are unevenly distributed, the maximum being in the last horizon. Both lime and magnesia have been illuviated in the sub-soils. This accumulation has caused restricted drainage in the last horizon. Potash and phosphate contents are average. The Type IV/II clay loam soils are fairly rich in sesquioxides which follow the trend of clay, with maximum accumulation in the fourth horizon. Alumina and iron follow a trend similar to that of sesquioxides. The soils are calcareous in the sub-soil. Magnesium is uniformly distributed in the profile. The soils are rich in potash and phosphate. The total water soluble salts concentration is medium, more or less uniformly distributed, the maximum being in the last horizon.

DISCUSSION

The alluvial soils of Uttar Pradesh are great soil groups having soils in all stages of genetic development. Detailed study of the soils indicates that topography, together with climatic conditions, has played a most important role in the development of Baheri zone soils. The flood-basin soils, where silting is still in progress, and there is no disti ct profile development as yet, and calcium carbonate is present throughout the profile in amorphous and fine nodulated form, have been classified as Type I soils. The upland soils, where profile development has taken place and there is illuviation of sesquioxides and clay to the lower hor:zons and which are more or less mature and freely drained have been classified as Type IV soils. The soils having

characteristics identical with Type IV soils on the surface but with restricted drainage on account of *kankar* formation in the sub-soil, have been classified as Type IV/II soils. These are also of old alluvium which are in the process of maturity. The maturity to the extent of Type IV soils has been hampered in Type IV/II soils owing to silting from the vicinity and restricted drainage. The calcium from the surface layers has leached down in Type IV/II soils and has precipitated at a depth from 15 in. to 72 in., depending upon the texture of the soil. The soils of each type have been further grouped on the basis of texture of the surface, as well as sub-soil, into textural sub-types.

For sugarcane cultivation Type I soils do not seem to need high doses of nutrients and more than one or two pre-monsoon irrigations. These soils may not be able to save the cane crop from lodging if high doses of nutrients are given. Fertilizers like ammonium sulphate or ammonium chloride with any organic manure in 1 : 1 ratio can be used without any adverse effect on the soil; whereas in Type IV and Type IV/II soils, high doses of acidic manures like ammonium sulphate or ammonium chloride without plenty of organic matter (say, at least in the ratio of 1 : 2) may prove detrimental to the soil in due course of time. These soils respond very well to high doses of manure with proportionate irrigations. Three to six pre-monsoon irrigations may be required.

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CORRELATION BETWEEN SIZE OF HOLDINGS AND AVERAGE YIELD OF SUGARCANE PER ACRE IN UTTAR PRADESH

By

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Introduction

At the instance of the Indian Council of Agricultural Research, certain statistical data were collected during the two seasons (1942-43 and 1944-45) from the Cane Development Zones of U.P. with a view to studying whether there is any correlation between the size of holdings of a cultivator and the average yield of cane obtained by him. A brief account of the results obtained is given in this note from which it would be seen that, during both the years in which the survey was carried out, no statistical correlation could be established.

During both the years, information was collected in a standard form, showing the name of the district, range and zone together with (1) name of village, (2) serial number of grower, (3) name of grower, (4) total area of holding, (5) area under sugarcane giving serial number, khasra number and area in acres, (6) variety of cane, (7) yield in maunds, (8) type of soil, (9) previous crop, (10) treatment of standing crop i.e. number and kind of irrigations, manurings, earthings, hoeings etc., (11) seasonal conditions and (12) general remarks.

Results obtained in 1942-43

The data thus collected during the first year (1942-43) from the Eastern, Central, Rohilkhand and Western Ranges of U.P., covered in all 68 cane development zones and related to 748 individual holdings.

As a preliminary study, the frequency distributions of the 'average yields per acre' and the 'sizes of holdings' were examined, both range by range and for all the ranges together. The distribution of yields was more or less normal in all cases. The distribution of the sizes of holdings on the other hand was distinctly non-normal with proportionately larger number of smaller-sized holdings than of bigger sizes. It is not possible to say whether this gives a correct representation of the actual distribution of the various sizes of holdings in the State or whether there has been a real bias in selecting a larger number of smaller-sized holdings in each zone than larger-sized ones, as the selection of holdings cannot be regarded as conforming to strict principles of randomisation. However, it is assumed that the holdings form a fairly representative sample of the areas included. On a rough classification for instance the following number of holdings fell in each type of holdings (Columns 1 and 2 of Table I):—

Table I

Area of holding in acres	Number of holdings	Average yield in mds. per acre
Up to 6	495	$464 \cdot 70 \pm 7 \cdot 52$
Above 6 up to 12 ..	130	$473 \cdot 85 \pm 16 \cdot 09$
Above 12 up to 18 ..	79	$473 \cdot 73 \pm 20 \cdot 69$
Above 18 up to 26 ..	44	$490 \cdot 91 \pm 26 \cdot 52$

This shows that 66 per cent of the total number of holdings examined were less than 6 acres in area.

In column 3 of Table I, the average yields in mds. per acre for the four classes of holdings as worked out from their respective frequency distributions are given together with their respective standard errors. It is clear from this preliminary examination itself that although holdings of the size of above 18 acres show a slight increase of about 26 mds. of cane per acre as compared to the smallest-sized holdings (areas up to 6 acres), the difference is only of the order of the standard error and hence cannot be regarded as statistically significant. Between the various intermediate classes also, there are obviously no significant differences in the average yields per acre.

A more detailed classification of the different sizes of hodings with the corresponding average yields per acre is given in Table II.

TABLE II

Area of holding in acres	Number of holdings	Average yield in mds. per acre
Up to 2	228	476·8
Above 2 up to 4 ..	162	439·2
Above 4 up to 6 ..	105	477·9
Above 6 up to 8 ..	45	482·8
Above 8 up to 10 ..	53	475·9
Above 10 up to 12 ..	32	457·8
Above 12 up to 14 ..	23	462·0
Above 14 up to 16 ..	33	491·7
Above 16 up to 18 ..	23	459·8
Above 18 up to 20 ..	17	448·5
Above 20	27	507·6

This again shows that there is no particular kind of ' trend ' in the average yield figures with the increase in areas of holdings. Holdings with areas larger than 20 acres show an increase of about 30 mds. per acre over the smallest-sized holdings (less than 2 acres each), but this also can only be regarded as due to chance, as can be seen from the high and low values which occur for the various intermediate sizes.

A two-way correlation table for the 748 holdings was formed and the question whether there is at all any regression of average yield per acre on the size of holdings was studied for the whole set of data by the method of analysis of variance. The following table gives the results of the analysis.

TABLE III

Variance due	Degrees of freedom	Sum of squares	Mean squares
Between size of holdings ..	10	108·73	10·873
Within classes	737	8760 71	11·887
Total	747	8869·44	..

This shows that the variation between the different classes of holdings is even less than that of the average variation within the various classes. Our conclusion from the preliminary examination of the data is thus confirmed by the statistical analysis viz., that there are no significant differences as far as yield per acre is concerned between the 11 classes of holdings in which the data have been classified according to size of holdings.

It is hardly necessary to proceed further and examine whether there is any significant linear regression between the eleven ' area ' classes and to compare the deviation from linear regression if any with the variation within classes. However, it is of some interest to note that when the 10 d.f. was split into due to ' linear ' regression (1 d.f.) and remainder (9 d.f.), we got a mean square of 8·82 only for the former, which is much less than the ' within class ' variance.

The *correlation ratio* was also calculated by the usual formula. The value obtained was 0·1104, which is obviously of no significance.

Hence it may be concluded as a result of the examination of the present sample of data that there is no statistical correlation between the ' area of holdings ' and ' the average yield per acre ' of sugarcane.

Holdings having areas above twenty acres, show a slight increase in average yield as compared to very small holdings, but this increase is not statistically significant.

Results obtained in 1944-45

To confirm the above results, the enquiry was repeated on almost identical lines during the 1944-45 season. There were 622 holdings distributed in 18 districts, the number of Cane Development Zones being about 45.

Out of this number, only about 580 holdings could be included in the frequency distribution studies and correlation studies, as the remaining holdings did not give reliable information.

The frequency distributions of the holdings according to 'yield' and according to 'size of holdings' were first studied, both range by range and for all the ranges together.

The distributions of the yields were more or less normal, as in the previous enquiry; while the 'sizes of holdings' gave J-shaped distributions with a very large number of holdings with small areas and only a few holdings with bigger areas.

An idea of the average size of holdings in the different ranges can be obtained from the following table.

	Average size of holdings (acres)
Western	$10 \cdot 13 \pm 0 \cdot 65$
Rohilkhand	$7 \cdot 87 \pm 0 \cdot 72$
Central	$7 \cdot 56 \pm 1 \cdot 24$
Mid-Eastern	$5 \cdot 39 \pm 0 \cdot 44$
Eastern	$6 \cdot 83 \pm 0 \cdot 93$
All ranges	$7 \cdot 39 \pm 0 \cdot 31$

Bearing in mind that the holdings considered relate only to areas under the Cane Development Zones these figures do give a rough idea of the size of holdings in different ranges of the State.

As in the previous year, as a preliminary step, the holdings were divided into four classes according to their size and from their respective frequency distributions, the mean yields and their standard errors were calculated. The results (Table IV) show that 53 per cent only of the holdings examined were less than 6 acres in areas as compared to 66 per cent in 1942-43. The mean yields show very little variation, the difference between the smallest class and highest class itself being much less than the S.E. Obviously there seems to be no relationship between the area of a holding and its average yield.

Table IV

Area of holding in acres	Number of holdings	Average yield in mds. per acre
Up to 6	302	$398 \cdot 87 \pm 8 \cdot 85$
Above 6 up to 12 ..	119	$388 \cdot 45 \pm 12 \cdot 58$
Above 12 up to 18 ..	46	$383 \cdot 93 \pm 20 \cdot 83$
Above 18	112	$404 \cdot 90 \pm 15 \cdot 66$

A more detailed classification of the different sizes of holdings with the corresponding average yields is given in Table V.

This again confirms that the average yield is quite independent of the size of the holding. The mean yield of holdings with areas between two to four acres is the same as that of holdings with areas of 20 to 60 acres.

The two-way correlation table (Table VI) showing the relationship between the size of holdings and the average yield per acre does not also indicate any association between the two factors.

By combining the 'columns' and 'rows' with too small frequencies in the table a contingency table was first formed and the coefficient of mean square contingency calculated. The value obtained was $+0 \cdot 228$. This does not indicate any high degree of association.

TABLE V

Area of holding in acres	Number of holdings	Average yield in mds. per acre
Up to 2	150	339·2
Above 2 up to 4 ..	82	407·7
Above 4 up to 6 ..	70	387·4
Above 6 up to 8 ..	53	377·3
Above 8 up to 10 ..	34	418·3
Above 10 up to 12 ..	32	371·5
Above 12 up to 14 ..	18	402·3
Above 14 up to 16 ..	15	392·8
Above 16 up to 18 ..	13	387·8
Above 18 up to 20 ..	22	396·3
Above 20	90	407·0

TABLE VI

Showing correlation between (1) *Size of holdings and* (2) *Average yield of sugarcane per acre* (1944-45)

Yield in mds. per acre	AREA OF HOLDINGS IN ACRES															
	0–2	2·1–4	4·1–6	6·1–8	8·1–10	10·1–12	12·1–14	14·1–16	16·1–18	18·1–20	20·1–22	22·1–24	24·1–26	26·1–28	28·1–30	Above 30	Total
51–100	2	1	1	1	..	..	..	1	1	..	..	..	..	..	..	3	10
101–150	9	6	..	1	..	..	1	..	..	1	..	..	1	..	1	2	22
151–200	8	5	9	4	..	2	..	1	..	1	1	..	1	2	1	3	38
201–250	6	7	6	3	1	1	4	2	1	..	1	..	..	1	..	..	33
251–300	20	7	7	9	6	5	1	1	2	2	..	..	..	..	..	9	69
301–350	13	7	6	11	8	7	5	1	3	2	..	..	4	2	1	10	80
351–400	27	12	12	7	10	6	1	2	2	6	2	3	2	1	2	8	103
401–450	18	9	10	6	5	3	2	1	..	4	1	..	2	..	..	3	64
451–500	20	15	9	4	2	5	1	3	2	3	1	1	2	1	..	2	71
501–550	9	5	5	1	..	2	..	..	1	2	..	..	..	..	..	..	25
551–600	8	2	2	1	1	..	1	1	1	..	..	1	1	..	..	1	20
601–650	4	2	2	3	..	1	1	1	..	..	..	..	2	..	1	5	22
651–700	4	3	1	..	..	..	..	1	..	..	..	..	2	..	..	1	12
701–750	2	1	..	2	1	..	1	..	..	1	..	1	..	..	..	1	10
Total ..	150	82	70	53	34	32	18	15	13	22	6	6	17	7	6	48	579

The analysis of variance method was also employed as in the previous enquiry and the results are given below:—

Variance due to	Degree of freedom	Sum of squares	Mean squares
Between size of holdings ..	15	75·021	5·001
Within classes	563	4459·811	7·922
Total	578	4534·832	..

The variation 'within classes' is even slightly greater than the variation between classes (though not significantly) and thus there can be no question of any degree of correlation.

The correlation ratio was also calculated by the usual formula and the value obtained was 0·1286 (statistically non-significant). During 1942-43 the corresponding value was 0·1104 (non-significant). The simple product moment coefficients of correlation between the size of holdings and average yield of cane obtained range by range are given below:—

Range	Coefficient of correlation	Remarks
Western	+0·0560	Not significant
Rohilkhand ..	—0·0045	,, ,,
Central	+0·2353	,, ,,
Mid-Eastern ..	—0·0627	,, ,,
Eastern	—0·0093	,, ,,
State	+0·0053	,, ,,

It will be seen that the values are all small and that there is no correlation between size of holdings and average yield in any of the ranges studied.

Conclusion

The two years' results confirmed that within the range of holding sizes considered (less than 30 acres) there is no appreciable correlation between size of holdings and 'average yield of sugarcane per acre'.

It is emphasized that the conclusions relate only to Development Zones (Reserved areas) from which holdings were sampled, but are not likely to differ in the remaining tracts of the State as well.

EFFECT OF PHOSPHORUS DEFICIENCY ON VARIOUS NITROGENOUS FRACTIONS OF SUGARCANE

By

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Introduction

NITROGEN absorbed from the culture medium is easily taken up either in the form of ammonia or nitrate. The cationic uptake of ammonia differs from the absorption of anionic nitrate particularly in the manner in which it is elaborated into various organic nitrogenous substances. One of the essential factors in the initial process of the formation of nitrogenous compounds is the rapid uptake and accumulation of these two forms of nitrogen from the culture medium. The ammoniacal form, as it accumulates in the living cells, is immediately detoxified by its conversion into amino acids and amides. In fact, the intensity of transamination depends upon the quantity of ammonia accumulated and the degree of toxicity that such accumulations cause to the absorbing cells. The nitrates differ in this respect from ammonia primarily because of their nontoxic nature, causing no appreciable damage to the metabolic processes of the absorbing cells. The nitrates, however, are not utilized directly in the upgrade process of nitrogen metabolism. They are, therefore, reduced to ammonia before they could be effectively utilized in nitrogen metabolism.

Comparative studies on various crops have shown varying effects of nitrate and ammoniacal forms of nitrogen and have stressed the physiological significance of the ratio of NH_3:NO_3 in the metabolism of absorbing cells. Investigations conducted particularly on the effects of phosphorus deficiency have shown that absence of this element primarily affected the reducase activity of the absorbing cells with the result that the nitrates taken up by the plants were not so easily reduced to the ammonia stage for further elaboration. It is also suggested that in the absence of energy bonds of phosphorus, the process of phosphorylation and carbohydrate transformations within the plant are markedly influenced. Recent researches have also indicated that partial deficiency of phosphorus interferes with certain steps in the chain of reactions leading to the formation of proteins, with the result that protein content is reduced.

This paper depicts the specific effects of phosphorus deficiency on various organic and inorganic nitrogen fractions in the sugarcane plant. The extent of variations in the relative proportion of ammonia, amide, nitrate, 'rest', total soluble and insoluble nitrogen components under complete nutrition and phosphorus deficiency have been analysed under conditions of sand nutrient cultures.

Experimentation

The details of the layout plan of this paper have been given earlier by Lal and Singh (1957). The plant material for the analysis of these nitrogen fractions was prepared according to the method recommended by Loomis and Shull (1937). Freshly collected samples of leaf, stem and root were weighed to the nearest milligramme and killed in boiling 8 per cent alcohol. They were then preserved in stoppered bottles.

Total nitrogen was estimated in the dry matter of component parts by the modified Kjeldahl's method to include nitrate nitrogen (A.O.A.C., 1945). Other soluble nitrogen fractions, e.g. ammonia, amide, nitrate and 'rest' nitrogen were estimated in the alcoholic extract of preserved material. A series of extractions with alcohol were made till the complete extraction of the soluble nitrogen and carbohydrate fractions was ensured. An aliquot of the extract was evaporated to a volume of nearly 10 c.c. and made alkaline by adding calcium hydroxide in excess. The ammonia was distilled off at 45°C. under reduced pressure and absorbed in 0·02N sulphuric acid. The extract was then filtered to remove calcium and made up to 100 c.c. A 20 c.c. aliquot of this was pipetted for the estimation of amides, into Cullen-van-Slyke tubes and digested with 1·2 c.c. of sulphuric acid under a reflux for two and half hours. The excess of acid was neutralized with sodium hydroxide. After adding 20 to 40 c.c. of 52 per cent potassium carbonate to each sample, the tubes were connected in series with similar tubes containing a known volume of 0·02N sulphuric acid. A current of amomnia free air was drawn through these tubes for two hours; ammonia evolved was absorbed in standard acid and estimated as amide nitrogen.

Nitrate and 'rest' nitrogen were estimated in the residue left after the determination of ammonia and amides (Loomies and Shull, 1937). Total insoluble nitrogen was determined indirectly from the percentage

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of total nitrogen, minus the total percentages of all soluble nitrogen fractions mentioned above. This gave an indication of protein nitrogen in the plants.

The content of all the nitrogenous fractions was expressed as mgm. per 100 gms. of the fresh material of the leaf, stem and root. The comparative data on these nitrogen fractions was statistically analysed to show the extent to which ~~withholding phosphorus supply affected these~~ nitrogen fractions in the component parts of sugarcane at successive stages of the life cycle.

Experimental Findings

A. *Effect of Phosphorus Deficiency on Ammonia Nitrogen:*

The ammoniacal nitrogen was found to vary with age of the plant, the parts of the plant sampled for analysis and the conditions of nutrition under which the canes grew. In root, ammoniacal nitrogen increased to a relatively high values at 90 days in the life cycle in both complete-nutrient and phosphorus-deficient leaves. At later stages, ammoniacal nitrogen was reduced. In the stem, on the other hand, the complete-nutrient cultures showed a consistent fall with increase in age, reaching a low value at 225 days. The phosphorus-deficient sugarcanes behaved slightly differently in that the stem of such deficient plants showed an increase in ammoniacal nitrogen at 90 days but a ten-fold fall was also noted as the age advanced; a similar decline in other nitrogen fractions was also noted. In the leaf, on the contrary, the complete-nutrient cultures did not exhibit a marked decline in ammoniacal nitrogen. Leaves from phosphorus-deficient plants, however, exhibited a pronounced increase in this nitrogen fraction at 90 days followed by a fall (Table I A; Fig. 1).

Table I.

Content of various nitrogen fractions in the component parts of sugarcane (var. Co. 453) under sand nutrient culture

(Mgm. per 100 gms. fresh weight)

Age in days	Nutritional condition	Ammonia nitrogen	Amide nitrogen	Nitrate nitrogen	'Rest' nitrogen	Total soluble nitrogen	Total insoluble nitrogen	Total nitrogen
				A. *Leaf*				
45	CN	0·91	0·86	3·18	13·04	17·99	413·3	441·4
	—P	0·57	4·81	5·78	17·02	28·18	287·9	316·0
90	CN	0·76	4·09	5·46	65·91	76·22	398·4	474·6
	—P	2·59	14·05	18·05	57·85	88·54	294·4	382·9
135	CN	0·73	6·20	5·68	25·31	37·92	255·7	293·6
	—P	0·99	6·37	6·86	26·98	41·20	224·2	265·4
225	CN	0·68	6·88	6·12	25·90	39·58	196·5	236·0
	—P	1·27	7·99	6·59	32·23	48·08	214·9	262·9
				B. *Stem*				
45	CN	5·52	2·83	5·97	26·73	41·05	100·4	141·4
	—P	0·35	6·66	8·20	28·37	43·58	101·1	144·6
90	CN	3·24	25·68	9·71	87·69	126·32	82·7	209·0
	—P	4·33	31·29	20·46	71·62	127·70	116·9	244·6
135	CN	0·46	1·64	2·87	9·22	14·19	48·6	62·7
	—P	0·46	5·88	3·06	17·41	26.81	54·5	81·3
225	CN	0·16	0·54	7·37	11·18	19·25	48·1	67·3
	—P	0·42	3·58	3·94	23·07	31·19	71·1	102·2

TABLE I—(*Contd.*)

Age in days	Nutritional condition	Ammonia nitrogen	Amide nitrogen	Nitrate nitrogen	'Rest' nitrogen	Total soluble nitrogen	Total insoluble nitrogen	Total nitrogen
				C. *Root*				
45	CN	1·08	1·71	43·09	33·17	79·05	208·5	287·5
	—P	1·39	13·46	57·67	21·41	93·93	298·3	492·2
90	CN	1·66	8·02	22·85	27·17	59·70	108·2	167·9
	—P	2·02	5·75	19·84	41·41	69·02	69·8	138·8
135	CN	0·46	1·17	3·06	8·49	13·18	144·2	157·3
	—P	0·70	3·66	4·66	14·32	23·34	120·2	143·5
225	CN	0·37	1·88	4·08	12·88	19·21	149·4	168·6
	—P	0·61	3·25	4·88	15·45	24·19	123·7	147·8

Statistical examination of these effects conclusively indicated the outstanding response of age on the ammoniacal nitrogen content of sugarcane. Other main effects and first order interactions did not exhibit any significant response (Table II).

TABLE II

General response of age, treatments, plant parts and interactions on nitrogen fractions of sugarcane (var. Co. 453) *in sand culture*

Analysis of Variance

Due to	D.F.	M. S. S.						
		Ammonia nitrogen	Amide nitrogen	Nitrate nitrogen	'Rest' nitrogen	Total soluble nitrogen	Total insoluble nitrogen	Total nitrogen
Age	3	4·7030*	163·63	371·62	2260·88*	5324·3*	17390·4	30474·9
Treatments ..	1	0·0045	85·32	55·66	17·73	434·4	247·0	9·3
Plant parts ..	2	1·7862	50·21	439·52	384·39	106·4	87036·3*	33040·1*
Age × Treatments ..	3	2·1783	6·92	17·94	397·06*	0·6	953·9	902·1
Treatments × Plant parts	2	1·2856	0·36	0·59	1·62	3·7	4202·7	4751·6
Error	12	1·2412	50·18	169·87	109·02	782·4	5079·8	9534·2
Total	23							
S.E./observation ..	..	±1·114	±7·08	±13·03	±10·44	±27·97	±71·27	±97·64

* Significant responses

No significant reduction in ammoniacal nitrogen content was noted when the mean life-cycle responses were considered. The phosphorus-deficient plants showed significant fall in ammoniacal nitrogen at 45, 135 and 225 days; in comparison to the high values of this nitrogen recorded for the phosphorus-deficient canes at 90 days sampling. In complete-nutrient cultures, on the contrary, the reductions were more pronounced at 225 days in comparison to the values recorded at 45 days (Table III A; Fig. 1).

Component parts of the plant also showed the significant differences in the ammoniacal nitrogen content of the complete-nutrient or the phosphorus-deficient plants. These led to the conclusion that when the average life-cycle responses were considered, neither the plant parts nor the state of phosphorus deficiency were effective in improving or reducing the ammoniacal nitrogen content. A tendency to higher accumulation of this form of nitrogen in the stem of complete-nutrient plants was, however, noted (Table IV A; Fig. 1).

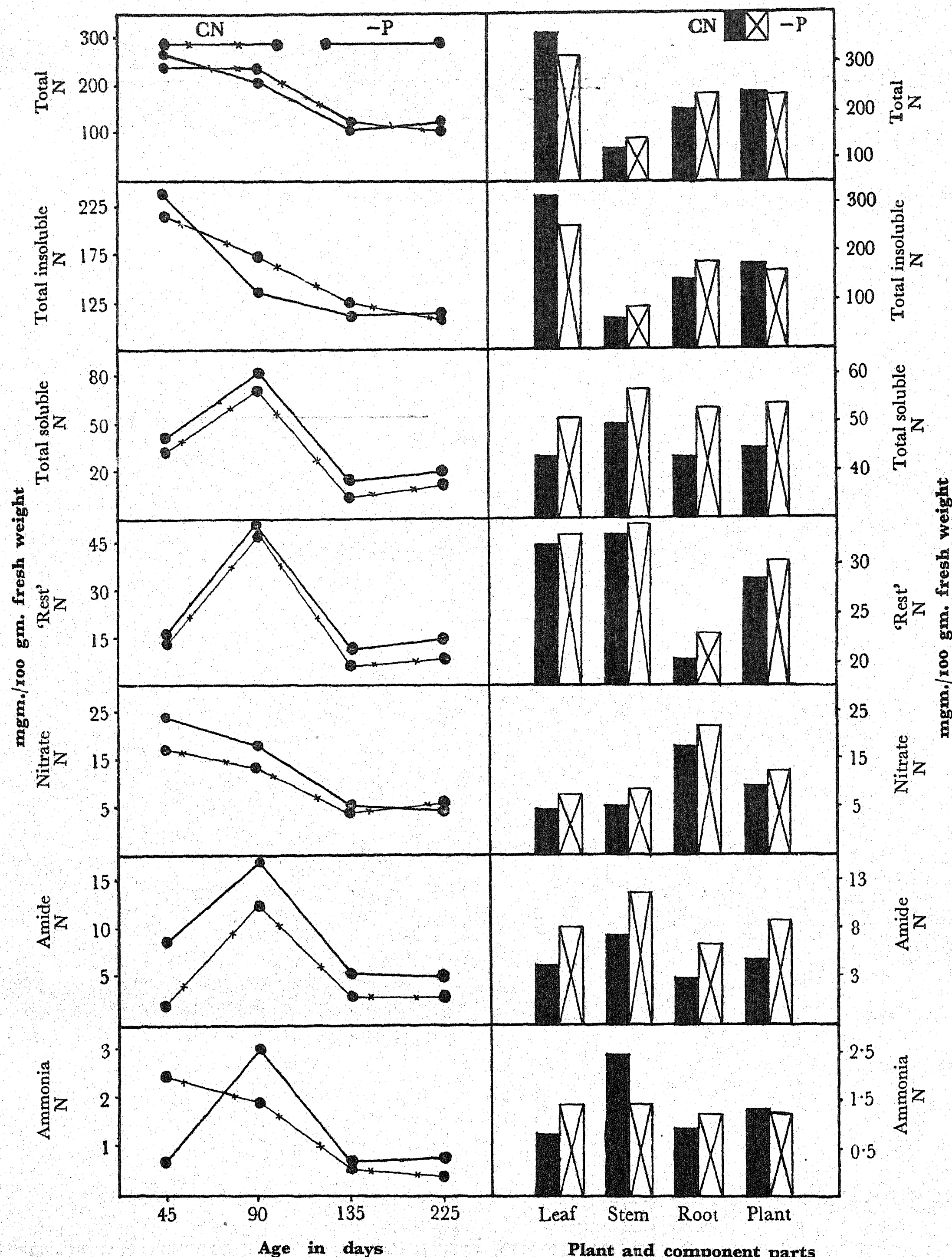

FIG. 1. Nitrogen fractions of component parts of sugarcane in relation to age and phosphorus deficiency under sand cultures.

TABLE III

Mean effect of age on the nitrogen fractions of complete-nutrient and phosphorus-deficient sugarcane (var. Co. 453) under sand nutrient cultures

Age × Treatment Interaction

Treatments	Age in days: 45	90	135	225	Mean of 12 values	C.D. at 5 per cent for means of
			A. Ammonia Nitrogen			
CN	2·503	1·887	0·550	0·403	1·3358	3 values =± 1·9829
—P	0·770	2·980	0·717	0·767	1·3085	6 „ =± 1·4004
Mean of 6 values	1·637	2·433	0·633	0·585	..	12 „ =± 0·9902
			B. Amide Nitrogen			
CN	1·800	12·597	3·003	3·100	5·1250	3 „ =± 12·686
—P	8·310	17·030	5·303	4·940	8·8958	6 „ =± 8·959
Mean of 6 values	5·055	14·815	4·153	4·020	..	12 „ =± 6·335
			C. Nitrate Nitrogen			
CN	17·41	12·67	3·87	5·86	9·787	3 „ =± 23·196
—P	23·88	18·12	4·86	5·14	12·999	6 „ =± 16·382
Mean of 6 values	20·648	15·395	4·365	5·497	..	12 „ =± 11·584
			D. 'Rest' Nitrogen			
CN	24·81	60·26	14·34	16·65	28·891	3 „ =± 18·586
—P	22·27	56·96	19·57	23·64	30·610	6 „ =± 13·126
Mean of 6 values	23·290	58·608	16·955	30·148	..	12 „ =± 9·282
			E. Total soluble Nitrogen			
CN	46·03	87.41	21·76	26·01	43·305	3 „ =± 49·796
—P	55·23	95·09	30·45	34·49	53·815	6 „ =± 35·168
Mean of 6 values	50·630	91·250	26·107	20·250	..	12 „ =± 24·868
			F. Total insoluble Nitrogen			
CN	240·7	196·4	149·5	131·3	179·50	3 „ =±126·734
—P	262·4	160·4	133·0	136·6	173·09	6 „ =± 89·608
Mean of 6 values	251·58	178·40	141·23	133·95	..	12 „ =± 63·362
			G. Total Nitrogen			
CN	290·1	283·8	171·2	157·3	225·61	3 „ =±173·645
—P	317·6	255·4	163·4	171·0	226·85	6 „ =±122·786
Mean of 6 values	303·85	269·47	167·30	164·13	..	12 „ =± 86·822

B. *Effect of Phosphorus Deficiency on Amide Nitrogen:*

Amide nitrogen in the roots of the complete-nutrient plants was highest at 90 days, while high amide nitrogen in phosphorus-deficient plants was recorded at 45 days in the life-cycle. With advance in age, however, a marked fall in amide nitrogen content was recorded. The stem of both complete-nutrient and phosphorus-deficient plants showed a relatively high percentage of amide nitrogen at 90 days when as high as 25·68 and 31·99 mgm. of amide nitrogen accumulated in complete-nutrient and phosphorus-deficient stems. In leaves, the effects were slightly different, inasmuch as the amide nitrogen content of complete nutrient plants showed a considerable rise with age, reaching the highest value at maturity. The phosphorus-deficient leaves, on the other hand, showed an increase in amide nitrogen between 45 and 90 days followed by a fall at later stages (Table I B; Fig. 1).

It was, however, important to note that none of the main effects and interactions had any significant effect on the amide content of sugarcane (Table II). The over-all plant part values in both complete-nutrient and phosphorus-deficient canes showed a relatively high amide nitrogen at 90 days. Phosphorus deficiency, unlike age, showed no significant variation in amide nitrogen (Table III B). In both the complete-nutrient and phosphorus-deficient cultures the stem showed a tendency to higher amide nitrogen than the other two component parts. The variations due to plant parts or the state of phosphorus deficiency were not found to be significant (Table IV B; Fig. 1).

TABLE IV

Mean effect of nutritional condition on the nitrogen fractions of component parts of sugarcane (var. Co. 453) under sand nutrient cultures

Treatment × Plant Part Interactions

Treatments	Plant Parts			Mean of 12 values	C.D. at 53 for means of
	Leaf	Stem	Root		
		A. *Ammonia Nitrogen*			
CN	0·770	2·345	0·893	1·336	4 values =± 1·7159
—P	1·355	1·390	1·180	1·308	8 „ =± 1·2137
Mean of 8 values ..	1·063	1·868	1·036	..	12 „ =± 0·9902
		B. *Amide Nitrogen*			
CN	4·508	7·673	3·195	5·125	4 „ =± 10·9775
—P	8·305	11·853	6·530	8·896	8 „ =± 7·3636
Mean of 8 values ..	6·406	9·763	4·888	..	12 „ =± 6·3350
		C. *Nitrate Nitrogen*			
CN	5·11	6·48	18·27	9·787	4 „ =± 20·0731
—P	8·32	8·92	21·76	12·999	8 „ =± 14·1962
Mean of 8 values ..	6·715	7·698	20·063	..	12 „ =± 11·5839
		D. *'Rest' Nitrogen*			
CN	32·54	33·71	20·43	28·891	4 „ =± 16·0825
—P	33·52	35·16	23·15	30·610	8 „ =± 11·3744
Mean of 8 values ..	33·030	34·434	21·788	..	12 „ =± 9·2816
		E. *Total Soluble Nitrogen*			
CN	42·93	50·20	42·79	45·305	4 „ =± 43·0917
—P	51·50	57·32	52·62	53·813	8 „ =± 30·4733
Mean of 8 values ..	47·214	53·761	47·703	..	12 „ =± 24·8676
		F. *Total Insoluble Nitrogen*			
CN	316·0	69·9	152·6	179·50	4 „ =± 109·797
—P	255·3	85·9	178·0	173·09	8 „ =± 77·650
Mean of 8 values ..	285·66	77·93	165·29	..	12 „ =± 63·362
		G. *Total Nitrogen*			
CN	361·4	120·1	195·3	225·61	4 „ =± 150·450
—P	306·8	143·2	230·6	226·85	8 „ =± 106·400
Mean of 8 values ..	334·10	131·64	212·95	..	12 „ =± 86·822

C. *Effect of Phosphorus Deficiency on Nitrate Nitrogen:*

Nitrate nitrogen content of roots in complete-nutrient and phosphorus-deficient plants was remarkably high during the early stages of 45 and 90 days and declined to low values at maturity. In stems and leaves the effects were also more or less similar nature, inasmuch as leaves and stems of deficient and complete

nutrient plants showed the highest concentration of nitrate nitrogen at 90 days' sampling. At subsequent stages, a decline invariably resulted (Table I C; Fig. 1).

Statistical analysis of these observations showed that none of the main effects and interactions attained the level of significance (Table II). The over-all plant part values showed the general tendency of declining nitrate nitrogen with advance in age, both under complete nutrition and phosphorus deficiency conditions. A tendency of higher nitrate accumulation in deficient plants was noted in a majority of the stages of growth (Table III C). The nitrate nitrogen was also significantly higher in the roots in comparison with both the leaf and stem; these on the contrary, did not differ significantly in this regard (Table III C; Fig. 1). The accumulation of nitrates in roots was possibly related to the roots acting like a reserve of inorganic nitrogen. The low rate of nitrate reduction and its elaboration into organic nitrogenous fractions may cause the accumulation of nitrates in phosphorus-deficient plants (Table IV C).

D. *Effect of Phosphorus Deficiency on 'Rest' Nitrogen:*

'Rest' nitrogen content of sugarcane consisting mostly of amino acids was highest at 45 days in the roots of the complete-nutrient plants. The phosphorus-deficient sugarcane roots, on the other hand, showed the highest amount of 'rest' nitrogen at 90 days. Further increase in age beyond the periods indicated above resulted in a marked decline in the 'rest' nitrogen content of the roots. The stem and leaf tissue also exhibited high 'rest' nitrogen content at 90 days under both complete-nutrient and phosphorus-deficient conditions. With advance in age, a decline took place. It was also indicated that at 90 days phosphorus-deficient roots showed a relatively higher percentage of 'rest' nitrogen in comparison to the control. In the stem and the leaf, on the other hand, phosphorus deficiency resulted in low content of 'rest' nitrogen than the control at 90 days (Table I; Fig. 1).

Statistical analysis of the data indicated the outstanding effect of age on the 'rest' nitrogen content of sugarcane. The first order interaction between age and treatment also exhibited significant response (Table II). This was clearly evident from the over-all plant part values of 'rest' nitrogen given in Table III D. Significantly high 'rest' nitrogen at 90 days' period of growth and a significant decline towards maturity were found to be characteristic. It was also noticed that the phosphorus-deficient tissues on an average showed a tendency to higher 'rest' nitrogen content towards later stages of growth. But the increases were found to be in-significant (Table IV C). The over-all age values, however, showed that the stem and leaf tissues were more or less alike in 'rest' nitrogen content, but the roots exhibited significant reductions in this fraction in comparison to the stem and leaves (Table IV D; Fig. 1).

E. *Effect of Phosphorus Deficiency on Total Soluble Nitrogen:*

The total soluble nitrogen content of the sugarcane plant also showed the following characteristic features:—

(1) A high total soluble nitrogen content of roots at 45 days followed by a marked decline as age advanced; (2) a high total soluble nitrogen content of the leaf and the stem at 90 days, followed by a decline at later periods; and (3) a tendency to higher soluble nitrogen under phosphorus deficiency (Table I).

Statistical analysis of the data, however, revealed that, barring age, none of the main effects and first order interactions were significant in effect (Table II). The over-all plant part values also characteristically depicted responses similar to those indicated above. Both the complete-nutrient and phosphorus-deficient plants showed the highest soluble nitrogen content at 90 days and a significant fall towards maturity. The deficient plants also showed a tendency to greater accumulation of total soluble nitrogen than the control, but significant effects were hardly evident (Table III E). It was also clear that the stem, the root and the leaf tissues did not differ significantly in their total soluble nitrogen contents when the over-all average values were considered (Table IV E; Fig. 1).

F. *Effect of Phosphorus Deficiency on Total Insoluble Nitrogen:*

The insoluble nitrogen content of the root, stem and leaf was relatively high at 45 and 90 days in comparison to the values recorded towards the last two stages of observation. During the juvenile phase, the leaves showed the highest total insoluble nitrogen, followed by the root and the stem in decreasing order. The P-deficient leaves were poor in total insoluble nitrogen. The deficient roots, on the other hand, showed higher insoluble nitrogen than that of the complete-nutrient roots at 45 days but not at other stages. The stem from the normal and –P plants did not differ significantly in this regard at 45 days in the life cycle. While these general effects were noted during the earliest stage, data recorded at subsequent samplings differed markedly. A general tendency of reduction in insoluble nitrogen content of P-deficient tissues was noted at majority of the stages in the life-cycle (Table I).

The total insoluble nitrogen content varied significantly with the plant organs. Other main effects and interactions were not significant (Table II). The over-all plant part values showed a significantly high total insoluble nitrogen content at 45 days followed by a characteristic fall with age. The phosphorus-deficient and complete-nutrient tissues were alike, inasmuch as they showed similar trend of variations; a tendency of lower insoluble nitrogen content in –P plants was also evident (Table III F). The over-all age values showed the highly significant increases in total insoluble nitrogen content of the leaf over that of the roots and the stem. The concentrations of such insoluble portions such as proteins, therefore, varied in the decreasing order—leaf> root> stem (Table IV F; Fig. 1).

G. *Effect of Phosphorus Deficiency on Total Nitrogen:*

Total nitrogen content varied with age. Beyond 90 days, total nitrogen content in the leaf and stem was reduced. In roots, however, maximum total nitrogen content was recorded during the earliest stage of 45 days. Phosphorus deficiency decreased the total nitrogen content at some stages and increased it at other periods (Table I; Fig. 1). Statistical analysis of the data showed the highly significant effect of plant parts. Other main effects and interactions were not significant at all (Table II). The average response of age on the total nitrogen content indicated a marked decline with each advance in age, reaching fairly low value at 225 days of the life-cycle (Table III G). The leaves, however, showed significantly higher values than the roots and stem, but the latter two did not differ markedly (Table IV G; Fig. 1).

Discussion

A. *Effect of Phosphorus Deficiency:*

Data recorded in various directions conclusively showed that the slackened supply of phosphorus resulted in wide variations in the various nitrogen fractions of sugarcane. These changes were more evident at certain critical stages of growth and metabolism than at other periods of the life-cycle. Thus, the ammonia nitrogen showed some tendency of increase under phosphorus deficiency at all the stages beyond 45 days. In contrast to this, the nitrate nitrogen was relatively high under P-deficiency conditions during early stages of 45 and 90 days. The high proportion of nitrates accumulating during the early stages showed that in spite of rapid growth of plants during the juvenile stage, the absorbed nitrates were not effectively utilized in the formation of organic-nitrogenous compounds. This appears to be due to poor reducase activity, as a result of which only a small quantity of ammonia was formed and made available for amide formation. When the excess of nitrates accumulated during the early juvenile period, why was the ammoniacal nitrogen relatively high under phosphorus deficiency conditions at 90 days' period? It appears that this accumulation of ammonia was the result of breakdown in the nitrogen metabolic reactions, as a result of which the excess of amino acids and amides were converted back to the ammonia stage. The accumulation of amide and the total soluble nitrogen in phosphorus-deficient canes side by side with the reduction in the insoluble nitrogen content at 90 days in the absence of phosphorus, indicated that deficiency of this macroelement interfered with the process leading to the synthesis of proteins. Phosphorus deficiency thus showed two-fold effects, the first being connected with low reducase activity and the second with the interference at the stage of protein synthesis. Attention in this connection may be drawn to the earlier work of Eaton (1949), who showed that in sunflower, phosphorus deficiency did not seriously affect nitrogen metabolism and no increase in soluble nitrogen content was recorded. In soya-bean, (Eaton 1950) phosphorus deficiency increased total soluble nitrogen, ammonia and amides. One of the basic factors responsible for this appeared to be interruption of protein synthesis beyond the amide stage resulting very often in proteolysis and accumulation of total soluble nitrogen and amides. The responses in mustard (Eaton 1952) were similar to those obtained for sunflower, but were in contrast to those noted in soya-bean. In sugarcane, in the present series, the responses were more or less identical to those recorded in soya-bean resulting in accumulation of amides, total soluble nitrogen and nitrates.

Further analysis of the ratios between various nitrogen fractions indicated that phosphorus deficiency improved amide/' rest ' (0·17–0·29), soluble/insoluble (0·25–0·31), soluble/total (0·20–0·23), amide/soluble (0·11–0·16), nitrate/soluble (0·21–0·24), and amide/insoluble (0·03–0·05) ratios. This again suggested some sort of breakdown in protein synthesis resulting in high amide/insoluble ratio. The greater proportion of amide/total soluble nitrogen also indicated the relatively higher accumulation of amides relative to other soluble fractions in the deficient tissues. Further, the high soluble/insoluble ratio in the deficient plants showed interference at some stage prior to the formation of protein, whereby the soluble fractions accumulated in relatively large quantities in comparison to insoluble. It was also made evident that under phosphorus deficiency the ratio of amide/' rest ' nitrogen (0·17-0·29) was relatively high, indicating that the amides accumulated in the tissues. On the other hand, deficiency of phosphorus resulted in low ammonia/nitrate (0·13–0·10), ammonia/soluble (0·03–0·02), and ' rest '/soluble nitrogen (0·63–0·56) content. The low ratio of ammonia/nitrate suggested poor formation of ammonia relative to nitrate, while a similar low ratio of

ammonia/soluble or ammonia/' rest ' showed that the soluble fractions particularly amides and amino acids accumulated more under phosphorus deficiency in comparison to accumulation of ammonia. While some of these effects were more characteristic during the early stages and not at other periods, the complex nature of the response of phosphorus deficiency on nitrogen metabolism, was evident.

B. *Effect of Age:*

So far as the age effect was concerned, the early juvenile stage appeared to be more important from the point of view of nitrogen metabolism than the later period of growth. That nitrogen metabolism was in a most active state during the early life-cycle was made evident from the high values recorded at 45 to 90 days for ammonia nitrogen, amide nitrogen, ' rest ' nitrogen, total soluble nitrogen and insoluble nitrogen content of sugarcane. The activity of the component organs in the formation and accumulation of these nitrogen fractions was correlated with marked improvement in the relative growth rate, leaf area development, and the development of various tissues. The declining growth activity and leaf area formation at later periods was, on the other hand, associated with poor content of these nitrogenous substances. The variations in nitrogen fractions were thus related to the changes in growth activity of the plant at various stages. The question of how far the content of soluble fractions was related to the process of carbohydrate metabolism and respiration will be discussed in a subsequent paper.

C. *Effect of Component Parts:*

Data recorded also indicate that metabolism of nitrogen was not confined to the leaf alone but was also noted to be actively going on in the root and in the stem. The order in which the component organs varied in their capacity of forming and accumulating these nitrogenous fractions is as follows:

Amide	stem > leaf > root
Ammonia	stem > leaf > root
' Rest '	stem > leaf > root
Total soluble	stem > root > leaf
Total insoluble	leaf > root > stem
Total nitrogen	leaf > root > stem
Nitrate	root > stem > leaf

It appeared, therefore, that the leaf was the principal part of the sugarcane plant which exhibited the highest efficiency in accumulating insoluble nitrogen fractions. The leaf being the centre of carbohydrate synthesis, such a response is to be expected. The roots, if at all helpful, appeared to accumulate more of nitrate nitrogen. The stem in a way, acted like a medium for the upward and downward transport of various fractions and acted as a sink in accumulating complex organic nitrogen fractions. The significance of these in the dynamics of growth and metabolism will be discussed in a later publication.

Summary

1. Estimations of various nitrogen fractions such as ammonia, nitrate, amide, ' rest ' nitrogen, protein and total nitrogen were made in sugarcane leaf, stem and root collected from complete-nutrient and phosphorus-deficient cultures.

2. The outstanding effects are of phosphorus deficiency (i) increased accumulation of nitrate nitrogen, (ii) reduced formation of proteins suggesting poor reducase activity and interference in the protein synthesis beyond the amide stage.

3. The greater accumulation of insoluble nitrogen, amide, ' rest ' nitrogen, and total soluble nitrogen during the juvenile phase (45 to 90 days) showed the important role that these organic nitrogenous substances played in the dynamics of growth and development of component parts during early stages.

4. The insoluble nitrogen compounds, consisting mainly of proteins, accumulated in the foliage and moved downwards towards the roots. The stem served as a channel of transport and storage and invariably showed high concentration of amide, ' rest ' and total soluble nitrogen.

5. Phosphorus deficiency also resulted in increased ratio of amide/' rest ', soluble/insoluble, soluble/total nitrogen; amide/soluble nitrogen, nitrate/soluble nitrogen and amide/insoluble nitrogen ratios, suggesting some breakdown at the protein formation stage resulting in higher accumulation of amides and soluble nitrogen fractions in general. Associated with this was also noted a poor accumulation of ammonia in comparison to nitrates and a relatively higher accumulation of amides and amino acids in comparison to ammonia in deficient cultures.

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PRELIMINARY STUDIES ON THE WATER-LOGGED SOILS IN THE HAMIRA FACTORY ZONE (PUNJAB)

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Introduction

On the basis of the genetic characteristics of the soil profiles, the soils of the Hamira Factory Zone were classified into four main categories viz. Type II, Type III, Type IV and Type VI. Occurrence of Type II—leached soils impregnated with calcium carbonate; Type III—leached soils impregnated with ferrugenous nodules and Type IV—heavily leached soils in the Jagadhri Factory Zone of the Punjab, has been reported from these laboratories (1954, a). Type VI (water-logged) soils were recorded on an area of about 10,000 acres on the North-western side of the Cane Development Circle, Tanda. In these areas, the water oozing out under the hydrostatic pressure flows on the surface. The position of the water-table fluctuates periodically during the year due to variations in atmospheric temperature, evaporation and precipitation; the fluctuation has great bearing on the various physical, chemical and biological properties of the soil.

Review

Das and others (1954, b) have classified the water-logged soils in the Hargaon Zone and named them as Type IV/II soils. They have also reported that quality of cane (Co. 527) was equally good on Type IV and Type IV/II soils in the month of February. Wali (1956, b) working on the bog soils in the Nizamsagar area (in Hyderabad State) has reported that the formation of these soils is due to sodium saturation of exchange complex resulting in excessive volume expansion of the sub-soil and, due to the internal pressure, water oozes out of the surface. Rege and Mascarenhas (1956, a) working at the Pamba River Sugar Factory (Kerala) have shown that yield of cane was not adversely affected in these soils due to floods in the preceding five seasons, but the quality of cane was greatly depressed especially in the year when the flood occurred after the arrowing of cane. They also reported that in the Pamba river valley, cane from the loam soils was found to be of good quality even prevailing under water-logged conditions for a period of about three months. However, in the cane-growing areas of the Punjab, work on water-logged soils has not been reported so far on these lines.

Soils

Besides studying the morphological characteristics of soil profiles and physico-chemical properties of the water-logged soils (Type VI), the potential fertility and cane quality were also assessed through crop-cutting experiments. Soil profiles (up to water-table depth) were opened during the dry season when the water-table had receded. The morphological characteristics and other analytical data of the typical profile is given below and in Table I.

Morpholigcal characteristics

(Village—Ghul, soil Type IV/Clay loam)

Depth	Description
0″– 6″	Light brownish grey; grey when wet; clay loam; compact; roots and insect holes present; moist and brisk effervescence with HCl.
6″–13″	Yellowish grey; brownish grey when wet; clay loam; compact; roots and insect holes present; brown specks of iron; moist and slight effervescence with HCl.
13″–24″	Brownish grey; grey when wet; sandy loam; single grain structure; roots scanty; brown specks of iron; moist and no action with HCl.
24″–53″	Greyish brown; brownish grey when wet; loamy sand; single grain structure; brown and blackish spots of iron; water oozes out and no action with HCl.
53″ onward	Water-table.

TABLE I

Physico-chemical analysis

Village-Ghul—Soil Type VI/Clay loam

Depth of the horizon	0″–6″	6″–13″	13″–24″	24″–53″
(Percentages on air dry basis)				
Clay ..	24·60	20·75	13·90	10·00
Silt ..	37·00	29·55	12·70	12·30
Sand ..	38·40	49·70	73·40	77·78
Calcium carbonate ..	1·25	0·77	..	..
Organic carbon (Walkley and Black Value) ..	0·477	0·222	0·105	0·066
Water-holding capacity ..	36·30	31·10	28·30	26·00
Sticky point moisture ..	27·80	23·50	17·10	16·40
Total ionizable salts ..	0·352	0·257	0·286	0·154
pH value ..	7·85	7·85	7·60	7·50
C/N ratio ..	5·32	3·85	3·40	2·35
Total nitrogen ..	0·089	0·057	0·031	0·028
CaO ..	0·987	1·064	0·686	0·637
P_2O_5 ..	0·105	0·070	0·105	0·122
K_2O ..	0·930	1·200	0·550	0·600
Exchangeable cations m.e. per cent—				
Exchangeable calcium ..	10·50	9·00	7·00	4·75
Exchangeable magnesium ..	2·50	2·10	1·70	1·60
Exchangeable sodium ..	2·86	2·91	2·77	2·94
Exchangeable potassium ..	0·31	0·47	0·54	0·53
Total exchangeable cations ..	16·66	13·12	12·16	10·91
Ex. Ca./Ex. Mg. ratio ..	4·2	4·28	4·11	2·96
Ex. Ca./Ex. Na. ratio ..	3·67	3·09	2·52	1·61

The brownish grey water-logged soils are characterised by high water-table and the concentration of soluble salts and calcium carbonate in the surface horizon.

The analytical data show that the soils are heavy in texture. Calcium carbonate and ionizable salts are present in high concentration in the surface layer and their percentages decrease with the depth of the soil profile. The pH value, organic carbon percentage, total nitrogen percent and C/N ratio, show regular decrease with the depth of the solum. Water-holding capacity and sticky point moisture value vary with the soil texture.

Studies on exchangeable cations show that the exchangeable calcium, exchangeable magnesium and total exchangeable cations are maximum in the first horizon and their percentages decrease in the subsequent sub-soil horizons. Ex. Ca./Ex. Mg. and Ex. Ca./Ex. Na. ratios also narrow down with the depth of the solum.

The soils are low to moderate in fertility. The high water-table goes to develop anaerobic conditions in the sub-soil. The repeated wetting and drying; swelling and shrinking has a profound effect on the physical conditions of the soils. These soils on drying become cake like and form a cap on the surface and have been observed to affect badly the germination of sugarcane setts when sown under high moisture conditions.

Crop Cutting Experiments

In all, 92 crop-cutting experiments were conducted on the various soil types in the Hamira Factory Zone during the three years, 1953-56, for studying the comparative fertility and cane quality of different soil types. Co. 312 is the main variety grown in this area. Co. L. 9 (a variety given out recently) was met with only on Type III soils. The results of these experiments, along with the juice quality data are given in Table II.

TABLE II

Soil Type	Cane Variety	Cane yield in mds./acre	Brix per cent	Sucrose per cent	Purity coefficient	Number of experiments
Type II ..	Co. 312	637·50	17·80	14·14	79·43	12
Type III ..	Co. 312	571·57	17·95	13·97	77·82	50
	Co.L. 9	538·71	17·40	14·30	82·18	11
Type IV ..	Co. 312	498·25	13·82	14·05	78·84	11
Type VI ..	Co. 312	431·00	18·40	14·14	76·84	8

The yield data show that the probable fertility status of various soil types is in the order Type II—Type III—Type IV—Type VI. Compared to other soil types, these water-logged soils have shown low fertility status. These results are, however, not in conformity with those recorded by Rege and others (1956, a).

The juice quality data, on the other hand, have shown no difference in cane quality in respect of various soil types. The percentage sucrose on Type VI (water-logged soils) was 14·14 as against 14·14, 13·97, 14·05 recorded on Type II, Type III and Type IV soils, respectively. These findings, though at variance with Rege, corraborate the findings of King (Director, Bureau of Sugarcane Experimental Station, Australia) who, from his experience on poorly drained Australian soils, also maintained that water-logged cane is not necessarily low in quality. Das *et al.* (1954 a) however, observed comparatively low juice quality of cane Co. 527 from water-logged soils in November, December and January, but the difference in quality of cane disappeared in February.

Summary

(1) The water-logged soils recorded in the Hamira Factory Zone are situated in the North-western areas of the Cane Development Circle, Tanda, covering an area of about 10,000 acres, and are characterised by high water-table and concentration of soluble salts and calcium carbonate in the A horizon.

(2) The soils are heavy in texture. The pH value, organic carbon percent, total nitrogen percent and C/N ratio, exchangeable magnesium, total exchangeable cations, exchangeable Ca./Ex. Mg. ratio and Ex. Ca./Ex. Na. ratio showed a regular decrease with the profile depth.

(3) The results of crop-cutting experiments indicated the potential fertility of various soil types in the order Type II—Type III—Type IV—Type VI.

(4) The juice analysis data show that water-logging of soils, during the rainy season, did not affect the cane quality (juice analysed in December).

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Research Notes

Effects of Manures on Germination of Sugarcane

APPLICATION of nitrogenous manures at the time of planting of sugarcane has been found to help its germination. Rege and Wagle (1939) observed that if *special seed areas* were heavily manured with nitrogen as top dressing and ammonium sulphate applied at the time of planting setts from these seed areas it would help in securing optimal germination. Application of concentrated manures like cakes and ammonium sulphate to supply 50 lb. of nitrogen enhanced germination of cane at Anakapalle, (1940, 1942). At the Sugarcane Research Institute, Pusa, the authors utilised the data of two experiments—one relating to optimal dose of ammonium sulphate in combination with single superphosphate for sugarcane crop, and the other about comparison of organic (compost) manure with inorganic (ammonium sulphate) manure in combination with single superphosphate used for sugarcane crop—conducted at three sites in Bihar during 1957-58 with a view to study the optimal dose and effect of different fertilisers on germination of sugarcane.

The experimental design in the case of the first experiment was split plot with four replicates. The single plot consisted of eight 40·5-foot-rows, 3′ apart. Each row was planted with 40 three-budded setts. The second experiment had randomised block design with six replicates. The single plot consisted of eight 60·5-foot rows, 3′ apart. Each row was planted with 60 three-budded setts. In both the experiments six rows, leaving aside border rows, were harvested for necessary record. After 45 days of planting the germination-count in all the plots was taken and the percentage of total number of buds germinated recorded.

Experimental Results: The data regarding germination count in the first experiment i.e. to find out the best dose of ammonium sulphate in combination with single superphosphate for sugarcane crop are presented in Table I.

TABLE I

Germination count of sugarcane under different treatments

Treatments	Experimental sites: North Bihar — Harinagar (Per cent)	South Bihar — Jineshwargarh (Per cent)	South Bihar — Warisaliganj (Per cent)	Remarks
M_0= Control (no manure)	26·72	35·41	49·10	The variety B.O. 14 was used at Harinagar and Jineshwargarh, Co. 419 was used at Warisaliganj.
M_1=60 lb. N+75 lb. P_2O_5 in North Bihar and 80 lb. N+60 lb. P_2O_5 in South Bihar	30·12	28·09	53·01	
M_2=120 lb. N+150 lb. P_2O_5 in North Bihar and 160 lb. N+120 lb. P_2O_5 in South Bihar	30·40	23·75	46·03	
M_3=180 lb. N+225 lb. P_2O_5 in North Bihar and 240 lb. N+180 lb. P_2O_5 in South Bihar	23·66	22·05	40·45	
M_4=240 lb. N+300 lb. P_2O_5 in North Bihar and 320 lb. N+240 lb. P_2O_5 in South Bihar	21·56	18·93	29·85	
S.E. (Mean)±	1·61	0·86	3·22	
C.D. at five per cent..	4·01	2·13	7·99	

Note.—Nitrogen was applied in the form of ammonium sulphate and phosphate in the form of single super-phosphate.

It is evident from the data given above that application of the first and second doses of the N, P combination at Harinagar (North Bihar) produced improvement in germination, but a significant decline was recorded with the succeeding doses. At Jineshwargarh, in South Bihar, the germination in the unmanured plots were the highest. The application of ammonium sulphate and single superphosphate depressed the germination of sugarcane, the reduction being more pronounced in plots treated with higher doses. At

Warisaliganj, in South Bihar, the first dose of nitrogen and phosphate increased the germination, but the successive doses had a depressing effect.

The experimental data presented above indicate that at Harinagar in North Bihar the application of nitrogen up to 120 lb. N along with 150 lb. P_2O_5 in the form of ammonium sulphate and single superphosphate had a very stimulating effect on germination, while in Warisaliganj in South Bihar the first dose of 80 lb. N and 60 lb. P_2O_5 applied as ammonium suphate and single superphosphate, was quite significant for the purpose and higher doses depressed the germination quite significantly. At Jineshwargarh in South Bihar where the soil conditions were completely different, the soil being very sandy in nature, the use of ammonium sulphate and single superphosphate had a very significant depressing effect. This may be due to the direct harmful effect of the fertiliser on the germinating bud.

The germination data of the second experiment i.e. comparison of organic manures with inorganic in combination with single superphosphate are furnished in Table II.

TABLE II

Germination count of sugarcane as affected by different kinds of manures (organic and inorganic)

Treatments	EXPERIMENTAL SITES			Remarks
	North Bihar	South Bihar		
	Harinagar (Per cent)	Jineshwargarh (Per cent)	Warisaliganj (Per cent)	
Control (no manure)	33·65	40·53	49·74	The variety B.O. 14 was used at Harinagar and Jineshwargarh and B.O. 11 at Warisaliganj.
Standard dose of manure Nitrogen and Phosphate in the form of compost and S.S.P.	38·05	47·28	54·20	
Standard dose of manure Nitrogen-half in the form of compost and half in the form Amm. sulph. and phosphate as S.S.P.	42·24	43·49	52·68	
Standard dose of manure in the form of Amm. sulph. and S.S.P.	42·94	26·86	55·81	
S.E. (Mean) ±	1·80	1·61	4·43	
C.D. at five per cent	4·37	4·16	..	

Note: Standard dose—60 lb. N+75 lb. P_2O_5 in North Bihar and 80 lb. N + 60 lb. P_2O_5 in South Bihar over a bsasl dose of green manure.

It is evident from the Table II that the highest germination count was recorded with the standard dose of manure in the form of ammonium sulphate and single superphosphate at Harinagar and Warisaliganj, the differences being significant in the case of the former but non-significant in case of latter. At Jineshwargarh where the soil is of very sandy nature the application of compost in combination with single superphosphate significantly increased the germination while the application of ammonium sulphate in combination with single superphosphate depressed it to a great extent.

It is thus evident from the data of the two experiments presented above that ammonium sulphate in combination with single superphosphate at planting-time had a greater stimulating effect on germination of sugarcane crop as compared to compost in normal soil conditions of North Bihar and South Bihar. At Jineshwargarh where the soil was extremely sandy in nature the application of compost in combination with single superphosphate had a very stimulating effect on germination. The use of ammonium suphate and single superphosphate, on the other hand, had a very significant depressing effect.—C. THAKUR and B. N. CHATTERJEE, Central Sugarcane Research Institute, Pusa, Bihar.

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* * * * *

Saccharum spontaneum, an Alternate Host of the Sugarcane Whitefly *Aleurolobus barodensis* Maskell

ALTHOUGH whitefly *Aleurolobus barodensis* Mask., is found all over the country as a serious pest of sugarcane, there is no report of any other plant serving as an alternate host for this insect pest.

During the course of the study of its biology a search for an alternate host was made at the farm of the Sugarcane Research Institute, Pusa (Bihar) and its neighbourhood. Last winter, its puparia were collected from early January till March from different forms of *Saccharum spontaneum.* There was severe infestation on narrow-leaved forms (Fig. 1) as compared to broad-leaved ones (Fig. 2). Puparia were also collected from the Burma form of the same species.

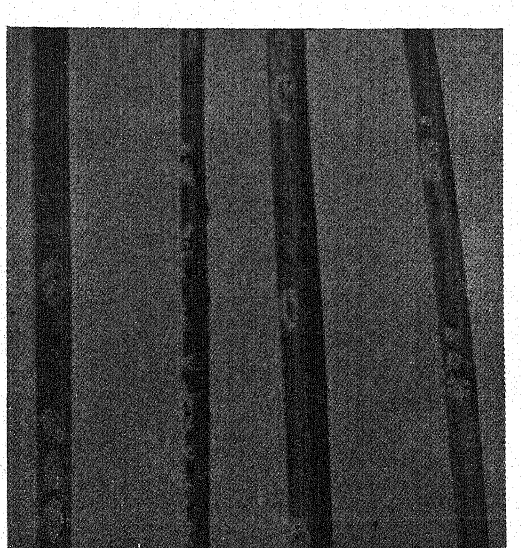

Fig. 1

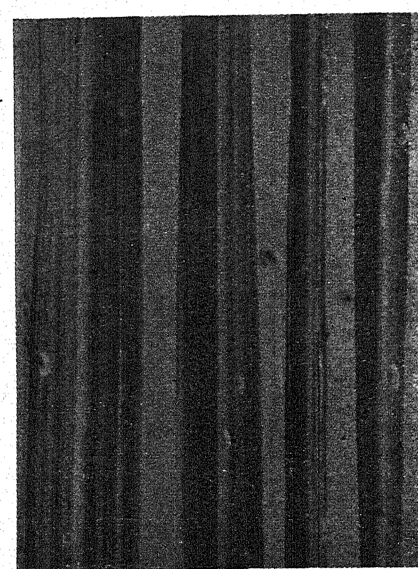

Fig. 2

It is interesting to note that the number of puparia was appreciably greater on these wild saccharums than on sugarcane during winter. Obviously they help the insect pest to tide over a critical period in its life cycle. This is, therefore, the first record of an alternate host plant for the sugarcane whitefly.—V. G. Prasad, Sugarcane Research Institute, Pusa, Bihar.

ADSALI CROP OF SUGARCANE IN BOMBAY STATE

By

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THE success of *Adsali* crop of sugarcane during recent years in the Deccan Canal Area of Bombay State has been phenomenal. It has now attracted the attention of progressive sugarcane growers all over the country. The large-scale cultivation of *Adsali* crop in the Deccan Canal tract has started only during the last decade. The word *Adsali* is a Marathi word meaning one year and a half. When sugarcane is planted in July-August it is called *Adasli* crop as it is harvested after one and a half years. The primary object of the *Adsali* crop is to get high tonnage of cane and early maturity.

The Deccan Canal tract at present comprises the areas under seven major canals commanding the zones of precarious rain-fall in the districts of Poona, Satara, Nasik, Ahmednagar and Sholapur. The distribution of area under sugarcane in Bombay State is as follows:—

(a) Total area under Sugarcane in Bombay State	1,92,189 acres.
(b) Area under sugarcane in Deccan	99,123 acres.
(c) Area cultivated by Sugar Factories situated in Deccan ..	23,257 acres.

(*Note:* The above figures are for the year 1954-55.)

Of the total area under sugarcane in Deccan Canal tract, it is estimated that about 50 per cent is under *Adsali*.

Soils of Deccan Canal Area

Soils of the Deccan Canal tract belong to the broad group of soils popularly known as the black cotton soils of India. The soils are mainly derived from Deccan trap rock. The most common rock found in the area is augite-basalt. The colour of the soils is of varying shades ranging from deep black to light brown. The soils are 2 ft. to 5 ft. deep underlain by partially-weathered *murum*. The pH of the soils is fairly high, about 8·5 to 9·0 In most of the soils in the area, exchangeable calcium contents are fairly high, varying from 35 to 60 m.e. per cent. In low-lying areas soluble salts are moderately high (about 0·4 per cent) and these soils require careful management.

Climate

Total rain-fall in the Deccan Canal Area varies between 16 in. and 25 in. Rain-fall is extremely erratic in distribution and years of good distribution are rare. The meteorological data for Padegaon Farm, which more or less represents the Deccan Canal Area, are presented in Table I.

Cultivation

Land is prepared by ploughing immediately after harvest of the previous crop of *Bajri*, gram or *Rabi Jowar*. Ploughing is done to a depth of 8 in. to 9 in. A second ploughing is done a month after the first ploughing. The soil is later pulverised with the help of a Norwegian harrow or wooden *maind* and worked with blade harrow a couple of times to bring it into fine tilth. Furrows are opened across the slope of the land, 3½ ft. to 4 ft. apart, with a heavy ridger.

(i) *Application of bulky manure*

A basal application of 30 to 40 cart loads (one cart load is 1,000 lb. approximately) of Farm Yard Manure is common. It is recommended that half of this quantity be applied just before the second ploughing and the remaining half applied in furrows just before planting. Preparation of compost from cane trash (available as a saving due to adoption of improved furnaces) is recommended in order to augment the supply of basal manure.

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TABLE I

Showing average temperatures and rainfall at Padegaon Farm

(Average from 1944 to 1954)

Month		Temperature (°F.)		Rain-fall in inches	Relative humidity %	
		Maximum	Minimum		At 8.00 a.m.	At 3.00 p.m.
1.	January ..	85·1	50·9	0·11	75·8	29·4
2.	February ..	89·7	53·2	0·02	67·7	20·8
3.	March ..	93·5	60·4	0·24	58·0	12·7
4.	April ..	98·6	67·1	0·45	58·3	18·0
5.	May ..	98·3	73·1	1·11	62·7	23·7
6.	June ..	90·8	72·3	2·48	74·9	49·9
7.	July ..	84·3	71·5	3·46	82·3	64·6
8.	August ..	84·0	69·8	2·13	83·4	64·3
9.	September ..	85·2	68·7	4·37	84·2	57·5
10.	October ..	87·6	66·6	3·06	81·4	43·4
11.	November ..	85·4	57·4	0·89	75·8	34·8
12.	December ..	83·6	50·3	0·18	76·1	32·1
	Average ..	88·8	63·4	Total 18·50		

(ii) *Planting*

Either wet or dry planting is done, depending upon the soil. In heavy soils dry planting is resorted to. The setts are planted 1 in. to 2 in. deep in the soil and slightly on the side at the bottom of the ridge to avoid risk of silting and damage by stagnation of water due to probable heavy rains in July. Nearly 10,000 to 12,000 sets are required per acre.

OPERATIONS DURING GROWTH OF THE CROP

Germination of *Adsali* crop is quite early. It starts from the second week and is practically complete within four to five weeks after planting.

(i) 2, 4-*D Spray*

Pre-emergence spraying with 2, 4-D at the rate of 1½ lb. in 100 gallons of water per acre about five days after planting followed by a second spray about 25 days after planting gives effective control of weeds. The advantage is that this method can be practised even under adverse conditions, when hand weeding cannot be done. T. is is the recent recommendation which is being followed in some factory estates on a large scale.

(ii) *Intercultivation*

After about two months of planting, the inter-space between the rows is stirred by means of a blade hoe or tooth cultivator. The operation is repeated two to three times at intervals of one month. In the course of interculturing, two *tagarnis* or light earthing-up operations with the help of a light iron plough are necessary.

(iii) *Earthing up*

Earthing up is done by working an iron plough first and then working a shovel tooth cultivator followed by a harrow and finally working with a Jamboo Ridger. The Ridger forms a clean furrow, pressing the soil

against the cane rows. The dressing of furrows and repairing of the water channels is however done by human labour.

(iv) *Top-dressing*

For *Adsali* crop a liberal application of nitrogenous fertiliser has been found to be advantageous; 450 lb. N is given in four doses as follows (Table II):—

TABLE II

	Sulphate of Ammonia		Groundnut Cake	
	N in lb.	Quantity Mds.	N in lb.	Quantity Mds.
1. Planting	45	$2\frac{3}{4}$	..	..
2. $1\frac{1}{2}$ to 2 months after ..	30	$1\frac{3}{4}$	175	26
3. 3 to $3\frac{1}{2}$ months after planting ..	45	$2\frac{3}{4}$	..	..
4. Earthing up	30	$1\frac{3}{4}$	175	26
	150	9	300	52

The proportion of N supplied by Sulphate of Ammonia and groundnut cake is 1:2. This proportion is found to help in ensuring a steady supply of available N to the crop.

Besides application of nitrogenous fertilisers, application of 100 lb. P_2O_5 in the form of superphosphate has given good response in medium and deep soils. There are indications that application of superphosphate also improves the *gul* quality and increases the C.C.S. Superphosphate is best applied at the time of planting six inches deep in the furrow in deep soils and half way down the ridge in shallow soils.

(v) *Irrigation*

Adsali crop requires a sure supply of irrigation water throughout its growing period. The number of irrigations along with acre inches of water required during different periods of growth of the crop is given in Table III.

TABLE III

Distribution of water quantities for Adsali *planting* (18 *months*)

Period and State	Acre-inches of water	Number of turns	Interval/ rotation
I. Planting dose	4·5	1	..
II. Germination and tillering stage (Mid-July to mid-October)	20·0	9	12 days
III. Early grand period of growth (Mid-October to end of December) ..	14·0	5	12 days
IV. Grand period of growth (Summer) (January to mid-June)	56·5	19	8 days
V. Second grand period of growth (monsoon) (Mid-June to mid-October) ..	32·10	9	12 days
VI. Maturity periods (Mid-October to mid-January)	23·80	7	12 days
Reserve Rain-fall	16·80	..	..
Total ..	167·70	50	..

HARVESTING

Adsali crop becomes ready for harvesting earlier than October and January planted cane. Harvesting is usually done during the period from November to February. The yield of *Adsali* crop is about 55 to 60

tons of cane per acre. With higher doses of trop-dressing, the yield could be stepped up even to 90 to 100 tons of cane per acre. However with high tonnage, the recovery is likely to go down.

Ratoon

Usually one ratoon crop is taken after harvest of *Adsali* crop. Immediately after harvest, the trash is removed, stubbles are cut off below ground level, the sides of ridges broken by means of an iron plough and the soil round about the stool is dug with the help of a small *kudali*. The land is then inter-cultivated and irrigated as and when required. For ratoon crop 300 lb. N in three or four doses is given. The proportion of N from sulphate of ammonia to cake is the same as for plant cane viz. 1:2. The yield of ratoon cane is 30 to 40 tons per acre.

Variety

Co. 419 is the most popular variety in the Deccan Canal area. However, new varieties viz. Cos. 775, 798 and 740, are now being tried on factory estates and on cultivators' fields.

Rotations followed

I	II	III	IV
Adsali	Adsali	Adsali	Adsali
Ratoon	Ratoon	Ratoon	Ratoon
Bajri and Tur	Paddy and Gram	Rabi—Jowar	Cotton

Advantages of *Adsali* Crop

The cultivation of *Adsali* is popular because of the following advantages:—

(a) High tonnage.
(b) Cane is ready for harvesting early in the season.
(c) Low cost of cultivation per ton.

(a) *High tonnage*

The *Adsali* crop gets the advantage of a longer period of growth. It gets the benefit of two rainy seasons when the atmospheric conditions are comparatively more humid. This helps in better development of the cane. The comparative yields of cane when planted at different time is given in Table IV.

Table IV

Comparative yield of cane for different planting times

(Average of four years' field trials—1946-50)

Name of the station	Types of soils	Planting time		
		July	October	January
Akluj	Medium black	61·74	48·37	39·0
Kopargaon		53·40	48·75	39·2
Deolali	Light shallow	58·24	43·20	35·8
Lakhmapur	" "	49·90	36·90	32·4
Average (of 3 years only) ..		55·8	44·3	36·3
Tons per month of growth period		3·1	2·9	3·0

Note: The manurial treatment for October and January planting was 300 lb. N while for July planting it was 385 lb. N.

(b) *November-December harvesting*

Adsali cane is ready for harvesting in November-December and it can stand in the field without much deterioration for two to three months, possibly because of low temperatures prevailing in winter. This confers a distinct advantage, inasmuch as the cane is thus available over a prolonged period for crushing in sugar factories.

(c) *Low cost of production*

It is very difficult to furnish comparative costs of cultivation for cane planted in different seasons. The extra expenditure to be incurred on *Adsali* crop is not one and half times the cost of plant cane. Extra expenditure is on irrigation and manuring only, the cost on cultivation remaining practically the same. Therefore, the cost of production per ton is about Rs. 3 to Rs. 4 lower than in the case of January-planted cane. However, under intensive cultivation, the soil is likely to deteriorate and it is therefore necessary to adopt judicious soil-management practices.

Conclusion

Adsali crop, because of the comparatively low cost of production per ton and high tonnage produced, is very popular with sugar factories and cultivators. Further, there are great possibilities of increasing the yield and improving the quality of cane by judicious application of fertiliser and by proper use of water. It is hoped that scientific research will be able to solve many of the problems that now face the growers of *Adsali* crop and it may be possible in the near future to produce more cane of better quality with less expenditure.

Miscellany

QUALITY OF SEED MATERIAL IN RELATION TO TIME OF PLANTING

It is well known that one of the factors contributing to a satisfactory germination of the sugarcane crop is the selection of appropriate seed material for planting. It is desirable that the age of the crop from which seed material is selected be of eight to ten months, so that optimum germination might be ensured.

With the gradual adoption of autumn planting in certain areas in North India, the question of proper seed material for autumn sowing is becoming an important factor. Autumn planting is similar to the *adsali* planting in vogue in the South, mainly Bombay-Deccan. Experience has shown that, for *adsali* planting, 'water shoots which are mainly in *adsali* crop give better stand and higher yields as compared to other seed material'. For autumn planting in North India the seed material is often taken from the previous autumn sown crop which by then is about 12 months or more in age.

During the autumn of 1957, while sowing some of the experimental plots, it was found that comparatively greater quantity of cane material had to be drawn for planting from the autumn-sown crop than from the spring-planted one. This was noticed to be due to paucity of healthy and good seed material in the former case consequent on heavier infestation of borer, greater number of damaged or sprouted buds more rooting of canes etc. A preliminary study was undertaken to obtain information on the relative quality of seed material from autumn and spring planted crops.

Three varieties, viz. Co. 453, Co. 527 and Co. 617 were taken up for study. One hundred canes were harvested at random from the autumn (12 months) and spring (eight months) planted crops, and observations recorded on the number of canes affected by stalk borer, (*Chilotraea auricilia*), the number of borer holes per cane, the extent of aerial rooting, the per cent selection of good setts and the weight of the same.

The data are summarised below:—

Variety	Crop from which seed material is taken	Per cent borer free stalks	Average number of borer holes per cane	Quantity of selected seed-cane pieces (per cent)	
				Number	Weight
Co. 453	Autumn	23·00	2·35	63·50	60·10
	Spring	82·00	0·27	67·30	67·40
Co. 527	Autumn	2·00	4·33	40·30	38·40
	Spring	47·00	2·28	47·40	47·30
Co. 617	Autumn	9·00	5·20	68·80	66·10
	Spring	69·00	0·54	75·70	80·70

The above data show that the autumn-planted crop suffers more from borer infestation, and consequently the percentage of healthy and good setts selected is less as compared to the spring-planted crop. The autumn-planted crop being 12 months or more in age tends to lodge, and the extent of rooting and sprouting of buds is greater-necessitating a very careful selection and handling of the setts.

Taking into account the above factors, it would appear that, for autumn sowing, seed material from spring-planted crop would be more suitable than from the autumn-planted one. It is, therefore, suggested that seed material be taken only from the spring-planted crop.—P. S. Gill and J. T. Rao (*Indian Institute of Sugarcane Research Newsletter*).

SPRAYING OF PHYTOHORMONES IN SUGARCANE

A TRIAL was conducted in the Central Sugarcane Research Station, Palur during 1956-57 to test the effect of pre-harvest spraying of phytohormones on sugarcane in increasing sugar content. The hormones tried were 2, 4-D butyl ester and 2, 4, 5-T/ester at 5, 10, 20 and 30 ppm, dieldrin and endrin at insecticidal concentrations. The unsprayed and water-sprayed plots were taken as control. The variety used was Co. 419. Juice analysis was conducted on the 8th, 15th and 22nd days after spraying.

It was observed from the juice analysis data that all the sprayed plots gave increases in C.C.S. per cent over the control. Of the various chemicals tried, dieldrin has given the maximum increase. Of the two esters 2, 4, 5-T/ester seems to be better than 2, 4-D butyl ester. In the case of both the esters, higher concentrations of 20 and 30 ppm were slightly better than 5 and 10 ppm up to a period of 7 days.—*Fortnightly Excerpts*, Directorate of Agriculture, Madras.

SUGARCANE CALLS ON THE SOUTH PACIFIC

POSSIBLE new Commercial varieties of Sugarcane and stronger defences against its diseaes in this country may result from a USDA plant exploration trip to the South Pacific.

Carl Grassl, ARS botanist and sugarcane breeder, returned last July from a five-month search for new germ plasm in New Guinea and surrounding islands. He and John Warner, Hawaiian Sugar Planters' Association plant breeder, sent back cuttings of 150 varieties of *Saccharum officinarum*, or "chewing canes"; 25 strains of *Saccharum edule*, canes with an edible, cauliflower-like head; and 40 varieties of *Saccharum robustum*, a wild ancestor of sugarcane.

In addition, they made 61 seed collections of *Saccharum robustum* and *spontaneum* and gathered 40 species of related wild grasses during the first expedition of its kind sponsored by this country since 1928. Both cuttings and seeds were gathered; the former can be collected from exceptional plants not in fruit, whereas the latter yield a more representative sample of available genotypes.

Most cuttings and seed were collected from the Australian part of New Guinea. Special search was made in Sepik River drainage area and the mountainous interior. Short trips also were made to many different rivers and native gardens in scattered parts of Dutch New Guinea and the British Solomon Islands.

With this substantial deposit in USDA's world collection of sugarcane at Canal Point, Fla., scientists plan to expand studies involving the breeding and selection of better adapted, higher-producing varieties possessing a higher sugarcane content, or other desired characteristics.

Addition of this important germ plasm to the collection will also expedite long-range research efforts to breed new varieties resistant to insect damage and to costly diseases such as mosaic, red rot, ratoon-stunting disease and others. Ratoon-stunting disease, for example, reduces the number and size of millable stocks. It alone accounts for an average annual loss of about 20 per cent of the sugar and syrup production from sugarcane plantings in Louisiana, Florida, Mississippi, Alabama, Georgia, Hawaii and Puerto Rico.

Sugarcane varieties have tended for many years to "run out". Scientists have attempted to cope with this problem by providing a flow of new, vigorous, high-yielding varieties. But this has succeeded only in temporarily checking the ravaging effects of several diseases that have become serious hazards from a build-up of infectious material or through rapid mutation. For this reason, a larger supply of germ plasm was necessary for conducting future research.

This recent collection is highly important to the sugarcane industry of the world, say ARS specialists, in view of the fact that native sugarcane gardens are rapidly disappearing with the advance of civilization in New Guinea and surrounding areas.

Those cooperating in the latest exploration for sugarcane germ plasm also included representatives of the Bureau of Sugar Experiment Station, Queensland, and the Australian, British, and Dutch Governments.—*Agricultural Research*, U. S. Deptt. of Agriculture.

RAYON FROM BAGASSE

CHEMISTS can now make clothing as well as food from sugarcane, according to the Nylonge corporation of Cleveland, Ohio, in the United States.

The Company says that it has developed a sound and economic process for making rayon from bagasse—the fibrous waste that is left after sugar has been extracted from sugarcane.

In the process, the bagasse is separated into two parts—the pithy and the fibrous portion which is used in the rayon making process. The fibres are treated with acid to remove the excess of other undesirable materials, and are then treated by a process known as "sulfate cooking". This procedure yields a pulp very similar to a wood pulp, and one which can be bleached by conventional process. This pulp can then be used, in the same way that wood pulp is used, to make rayon, the company says.—*American Reporter*.

HORMONE SPRAYING OF SUGARCANE CROP

AN experiment is being conducted now in "hormone spraying" of the sugarcane crop from air for increasing the sucrose content of the cane in parts of Muzaffarpur and Darbhanga districts in North Bihar by the Deputy Locust Entomologist of the Central Directorate of Plant Protection, Quarantine and Storage.

It is learnt that the spraying is being done at a subsidised rate in response to a request made by the Director, Sugarcane Research and Development, Pusa, (Bihar).

It is likely to be tried in South Bihar also if the experiment proves successful in North Bihar. Details are given in the following note.:

SPRAY PLANT HORMONE ON CANE TO INCREASE SUGAR RECOVERY

THE use of a plant hormone to increase sugar content of cane was first reported in Cuba. The hormone used was 2, 4-D (a synthetic product, well known as a Weedicide) which, when sprayed at very low concentrations in the form of sodium salt before harvest of the crop, increased its sugar content in a substantial measure. Work was undertaken at the Sugarcane Research Institute, Pusa (Bihar) to assess the potentialities of the treatment under conditions obtained in this country. Studies lasted over three consecutive seasons and consisted entirely of large scale trials under actual manufacturing conditions arranged in collaboration with the Sugar Industry in the State. Several trials were conducted on full scale, involving comparison of entire day's crushing of sprayed cane with whole day milling of unsprayed cane from the same areas. Results were overwhelmingly in favour of the treatment which gave an average improvement of 0·4 unit in sugar recovery. Pursuant to this finding, the Indian Central Sugarcane Committee launched country-wide trials. The results generally bore out the effect of the hormone as observed in Bihar, the All-India average improvement also working out to 0·4 unit in sugar recovery. In the light of the above findings, it was considered useful to bring out this brochure furnishing information relating to various aspects of the method and thus facilitate its adoption as a routine practice by the Sugar Industry.

How to apply the Hormone

Dissolve one ounce of 80 per cent sodium salt of 2, 4-D in 2 lb. of water in a small vessel by thorough stirring. Add this solution to 100 gallons of water in a drum. Rinse the small vessel twice with water and add the washings to the drum. Add eight ounces of " Albolineum " (or other sticker) to the drum containing 100 gallons and mix well, preferably by drawing the liquid from the drum by means of the spraying pump and returning the same through the delivery nozzle. The preparation is now ready for spraying. Ordinarily, 60 gallons of the solution are needed to spray an acre but where crop density is very high, larger quantities upto 100 gallons or more may be used, the object being to ensure thorough wetting of the leaves. The quantity of 2, 4-D (acid equivalent) applied per acre would thus be between 0·5 and 0·8 ounce. Spraying can be done by means of a petrol operated machine (See Plates I to IV, depicting the spraying process and the equipment needed for the work).

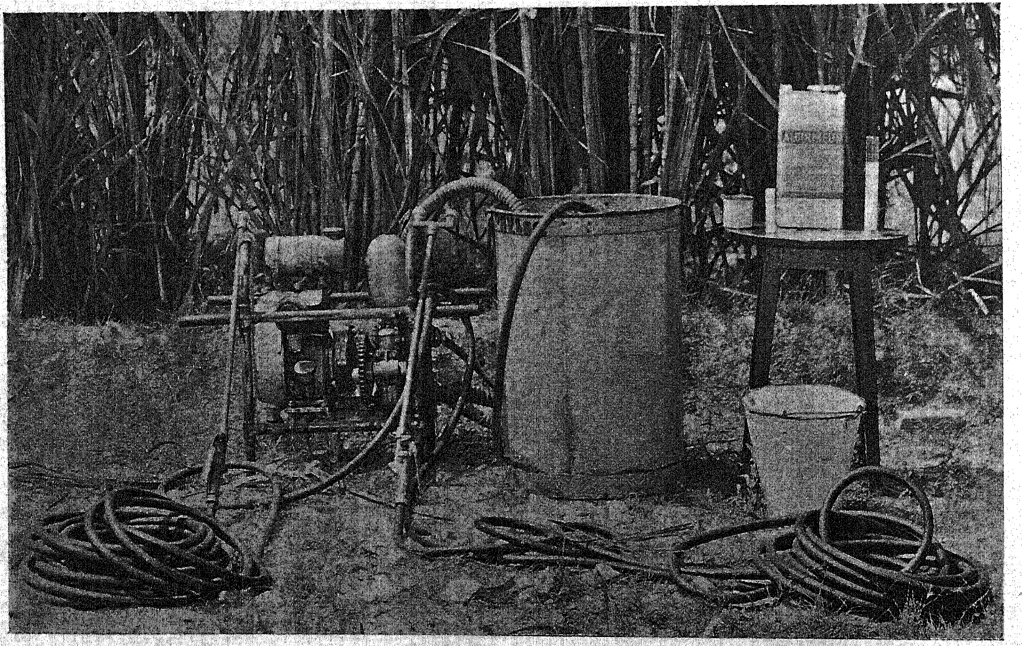

PLATE I. Showing the chemicals and equipment needed for spraying.

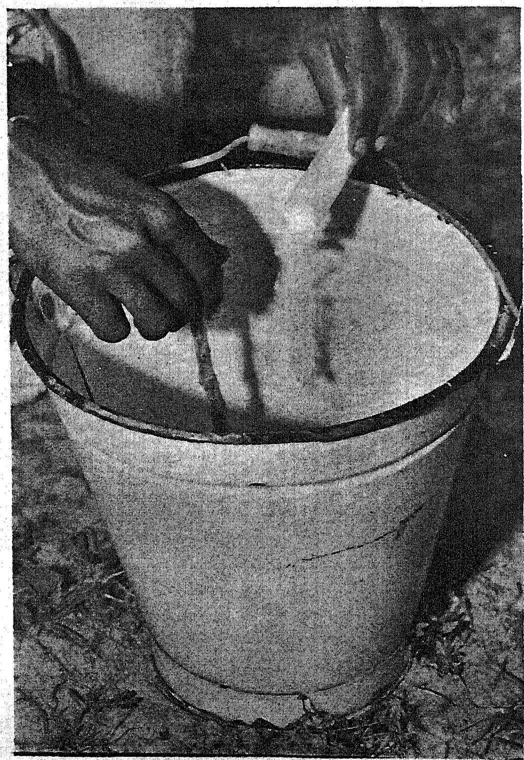

PLATE II. Preparation of 2, 4-D solution.

PLATE III. Showing the spraying of crop.

PLATE IV. A close view of spray.

During the 1957-58 season, aerial spraying was done from a Canadian Beever plane in several factory areas of Bihar (See Plates V to VII), rate of spraying per day being 600-700 acres. It is, however, necessary to have blocks under cane somewhat consolidated in nature. In case of aerial spraying, only two gallons are required to cover an acre. 0·6 ounce (or 28·3 grams) of 80 per cent 2, 4-D, sodium salt and 8 ounces of Albolineum (or other sticker) should, therefore, be dissolved in two gallons of water to prepare the spray fluid needed for an acre.

PLATE V. Spraying tank of the plane being filled with solution prior to take-off.

PLATE VI. The plane flies low over the crop to spray the solution.

PLATE VII. A view of the plane at work.

Cost of Hormone Spraying

The cost of chemicals used is insignificant, being of the order of 40-50 nP. per acre. Of this, 2, 4-D accounts for 13-17 nP., the balance being cost of the sticker. The major expenditure is that on spraying of the solution. This depends to a large extent on the distance from which water has to be carried. The total per acre cost with ground equipment varies from Rs. 2 to 3 (inclusive of chemicals) and it is only in rare cases, where water source is very remote, that the above limit is exceeded. In case of aerial spraying with a minimum assured area of 7,000 acres, the average cost (including chemicals) is estimated to be of the order of Rs. 4 per acre. With larger acreages, this will come down still lower.

The Treatment is effective under a wide variety of conditions

Response to hormone spraying has been obtained under a wide variety of conditions. It is equally effective in increasing sugar content in the sub-tropical North Indian belt and in the tropical south. Quite a large number of cane varieties have been tested (representing early, medium and late ripening groups) and all benefit from the hormone. Similarly plant as well as ratoon crop, autumn and spring plantings as also irrigated and unirrigated cane are equally responsive. Spraying can be done at any time between mid-November and end-February, its effect being noticed as early as two days after spraying and remaining unimpaired even after a period of 107 days. In Madras State, the treatment has been found effective in the special season as well. One limitation has, however, been noticed, viz. the comparatively poorer response when spraying has been done on a profusely flowered crop. It is, therefore, preferable to spray flowering varieties before the flowering stage.

The Hormone is harmless in all respects

The treatment has no adverse effect on the yield of cane and causes no damage to the leaves. On the other hand, it has been found to reduce field driage of the standing crop in hot weather, thus benefiting the grower also in the late season phase. The material is non-inflammable, non-corrosive and non-poisonous even in concentrations as high as 25 ounces in 100 gallons of water. There is, therefore, no possibility of any harm resulting to cattle fed on leaves sprayed with the chemical or to human beings handling it. Similarly, no adverse effect is possible on crops other than sugarcane at the very low doses of 2, 4-D used. The chemical has no deleterious influence on soil fertility even when applied in large doses directly to the soil.

A boon to the Sugar Industry

Pre-harvest spray of 2, 4-D affords an average benefit of 0·4 unit in sugar recovery under Indian conditions. Calculated on an acre-yield of 400 maunds, the extra production of sugar per acre is of the order of two maunds which means a net profit of over Rs. 50 per acre, after deducting the cost of the operation. Adoption of the method should, therefore, prove highly profitable to the Sugar Industry.—K. L. Khanna, *Director, Sugarcane Research and Development, Bihar, Pusa.*

COMMON SUGARCANE MEALY BUGS IN BIHAR (COCCIDAE: HEMIPTERA)

By

S. Mohammad Ali

(Sugarcane Research Institute, Pusa, Bihar)

Mealy bugs of sugarcane are widely distributed throughout the tropical and sub-tropical regions of the world. They are, however, regarded as a minor pest of the crop, although they have been reported to assume serious proportions under unusual drought conditions (Puttarudriah, 1954). Heavy infestations can adversely affect germination and growth of canes (Dick, 1956).

In India, Fletcher reported the occurrence of *Pseudococcus Sacchari* Cockerell, *Pseudococcus saccharifolii* Green and *Ripersia sacchari* Green on canes in different parts of the country as early as 1919. Ayyar (1941) further observed that *P. saccharifolii*, besides being fairly common on sugarcane in northern India, attacks chiefly *Saccharium arundinaceum* in Godavari district. He also mentioned that *Ripersia sacchari*, recorded for the first time on sugarcane in United Provinces (Uttar Pradesh), is observed mainly on Imperata grass in Tanjore and wild canes in northern Circars, and that *Trionymus sacchari* confines itself to sugarcane and a few grasses only. Gupta (1940) recorded *T. sacchari* in sugarcane fields throughout the year.

The author, while making an extensive collection of the coccid fauna of Bihar, found the three common species of mealy bugs which were determined by Dr. D. J. Williams of the Commonwealth Institute of Entomology, London, as *Ripersia sacchari* Green, *Saccharicoccus sacchari* Cockerell and *Pseudococcus saccharifolii* Green. There is, however, difference of opinion in the specific identification of the latter two mealy bugs. Puttarudriah (1954) regards *Dactylopius sacchari* Cockerell (1895), *D. sacchari* De Charmoy (1899), *D. sacchari* Green (1903), *Pseudococcus (D) saccharifolii* Green (1908), *Trionymus (P) sacchari* Cockerell (1922), *Pseudococcus boninsis* Kuwanan (1928) and *Coccus sacchari* (1913) as synonyms of genus *Saccharicoccus*, erected by Ferris (1950) for the single species *Sacchari*. Box (1953) has also mentioned that according to H. Morrison (1925; *J. Agric. Res.*, **31,** p. 485) some reference to the species *Pseudococcus saccharifolii* Green and *Saccharicoccus (Trionymus) sacchari* Cockerell, both of which appear to be distinct and valid species, actually refer to *Dysmicoccus boninsis* Kuwanan. A study on the behaviour, biology and morphology of the cane mealy bugs available in Bihar was, therefore, essential with a view to identify, while planning control experiments, which particular species of mealy bug, if at all they were different, was being dealt with. The work was, therefore, initiated in 1955 at the Sugarcane Research Institute Laboratory, Bihar, Pusa, and the results of studies are incorporated in the present paper.

Material and Methods

Ripersia sacchari was collected locally i.e. at Pusa, while *Saccharicoccus sacchari* and *Pseudococcus saccharifolii* at Haveli Kharagpur, Monghyr. To study the life cycle, gravid females were made to oviposit in separate petri dishes containing filter paper soaked in saturated solution of glucose. The nymphs on hatching were transferred with a camel-hair brush to cane plants (variety B.O. 11) grown in pots. Care was taken to ensure that all numphs hatched out from a cluster of eggs on a particular day were released on the potted plant the same day and plants so infested with different species of mealy bugs were isolated from each other to avoid mixing up of the species.

I. *Ripersia sacchari* Green

This mealy bug lives gregariously and is found in clusters beneath the leaf sheath on sugarcane nodes. At Pusa it was observed on varieties B.O. 11, B.O. 14, B.O. 24 and Co. 453. In February, 1955 ,it was found heavily infesting canes of Termite Control Experimental plots, but from the last week of the same month population started decreasing to such an extent that by the middle of March, it was rare even on ratoon and autumn-planted canes. During the period from the third week of March to early June, 1955 multiplication of this species was observed on the setts of spring-planted canes at Shahpur Maricha farm, Muzaffarpur. Later, on, i.e. from June onwards, its population increased and the percentage of attack went up to 65·6 per cent at the same farm.

PLATE I.

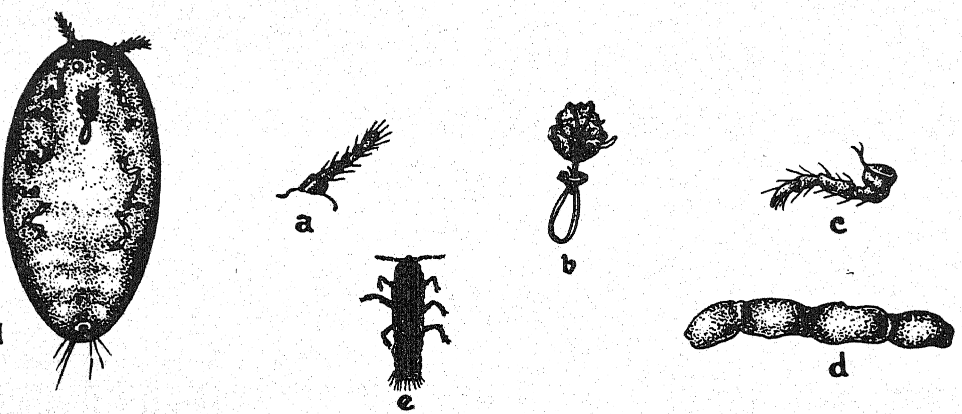

FIG. 1

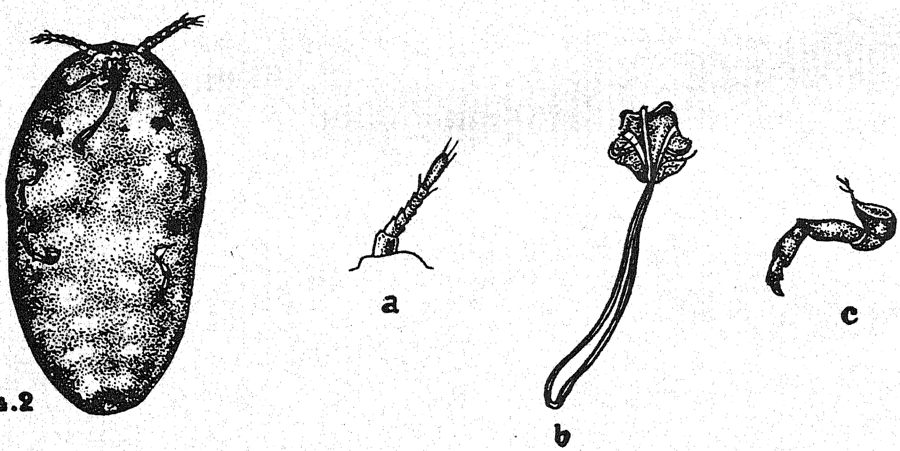

FIG. 2

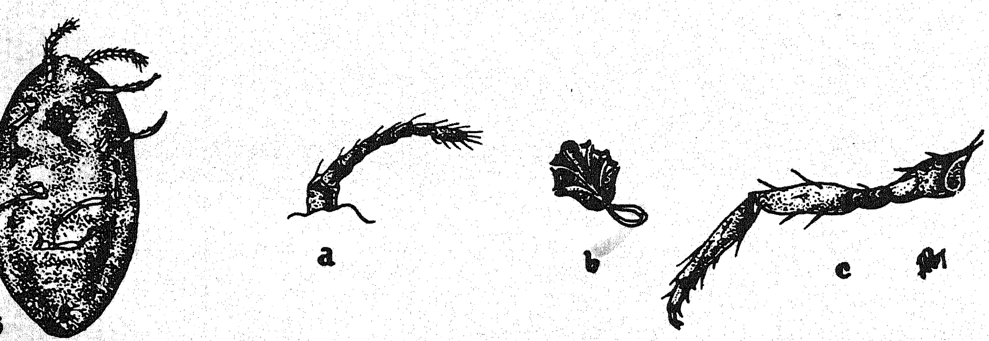

FIG. 3

FIG. 1. *Ripersia sacchari* adult female (x 10), *a*. Antenna (×63), *b*. Mouth parts showing loop of oral bristles (×45), *c*. Leg (×50), *d*. Eggs in chain (×28), *e*. First instar nymph (× 50).
FIG. 2. *Saccharicoccus sacchari* adult female (×10), *a*. Antenna (×60), *b*. Mouth parts showing loop of oral bristles (×49), *c*. Leg (×49).
FIG. 3. *Pseudococcus saccharifolii* adult female (×10), *a*. Antenna (×64), *b*. Mouth parts showing loop of oral bristles (×50), *c*. Leg (×48).

The adult female (Fig. 1) pinkish in colour, is somewhat flattened, soft bodied and sluggish and measures about 2·5 to 4 mm. long. The body is covered with white mealy secretion. A pair of short and 6-segmented antenna measuring 0·207 mm. each, is covered with sensory hairs on all the segments (Fig. 1a). A pair of small compound eyes is located posterior to the antennal socket. Mouth parts are well developed. The loop of mandibulary and maxillary bristles has a span of about 0·242 mm. (Fig. 1b). The tips of these bristles are enclosed within the labial groove roofed over by labrum. The leg with a single claw measures 0·293 mm. and is short, stout and hairy (Fig. 1c). Two pairs of spiracles, one on meso and the other on metathorax, are also present.

The eggs (Fig. 1d) are smooth and measure 0·31 × 0·14 mm. They are laid in a chain and lie underneath the abdomen. The chain is not visible unless the egg-laying female is kept on a petri dish or a transparent glass plate. The maximum length of a chain observed in the laboratory was about 3·5 cm. and it carried 120 eggs. The chain is extremely delicate and even the slightest mechanical disturbance is enough to damage it.

The incubation period of egg under laboratory conditions is about 14 hours when the average temperature was 82·1° F. and humidity 63 per cent. The freshly-hatched nymphs (Fig. 1e) remain for a short while beneath the abdomen of the mother. Thereafter they turn restive, move about and finally anchor themselves in the vicinity of the mother colony. The total life cycle is completed in about 18·6 days during April.

II. *Saccharicoccus sacchari* Cockerell

This is the common pinkish mealy bug (Fig. 2) attacking sugarcane nodes beneath the leaf sheath like *R. sacchari* (Fig. 4). Although dissimilar structurally, which will be obvious from a comparative study of the characters detailed in Table I, its behaviour and life-history are similar to that of *R. sacchari*.

TABLE I

Characters*	*R. sacchari*	*S. sacchari*
Antenna	Short, hairy and 6-segmented, 0·207 mm. in length (Fig. 1a)	Only a few hairs present, 7-segmented, 0·276 mm. in length (Fig. 2a)
Loop of oral bristles ..	Moderate in length the span being 0·242 mm. (Fig. 1b)	Very long; the span is 0·69 mm. (Fig. 2b).
Leg	Short, hairy and 0·293 mm. in length (Fig. 1c)	Moderately long, not hairy and 0·534 mm. in length (Fig. 2c)

*Studied under high magnification.

Puttarudriah (1954) has recently worked out the life history of *S. sacchari* and the present writer agrees with his observations. In brief, eggs enclosed in ovisac lie underneath the abdomen and the incubation period is less than eight hours. The total life cycle is completed in about 20 days during August.

III. *Pseudococcus saccharifolii* Green

Unlike *S. sacchari* this is pale yellowish in colour and found anchored on sugarcane leaf (Figs. 3 and 5). This mealy bug has comparatively stronger locomotory and sensory organs, but less developed organ of ingestion.

A pair of 8-segmented antennæ is provided with sensory hairs on all the segments and measures 0·483 mm. each (Fig. 3a). The mandibular and maxillary lopp has a span of only 0·120 mm. (Fig. 3b). The leg with well-chitinised setæ, specially on tibia is stout and 0·966 mm. long (Fig. 3c).

Eggs are contained in elongated ovisac probably secreted by accessory glands one to two days prior to oviposition. The egg-laying occurs in batches which gradually cause an increase in the length of the ovisac. By the time last batch of eggs are laid, the body of the female is raised to a vertical position with the anterior end attached to the substratum by the oral bristles. The female dies soon after oviposition. The incubation period of the egg varies from five to six days and the total life cycle is completed in about 25 to 28 days during August.

CONCLUSION

In the present paper a study of the behaviour, life cycle and morphology of *R. sacchari*, *S. sacchari* and *P. saccharifolii* has been made. The specific determination of *R. sacchari* is undisputed. But *Saccharicoccus*

PLATE II

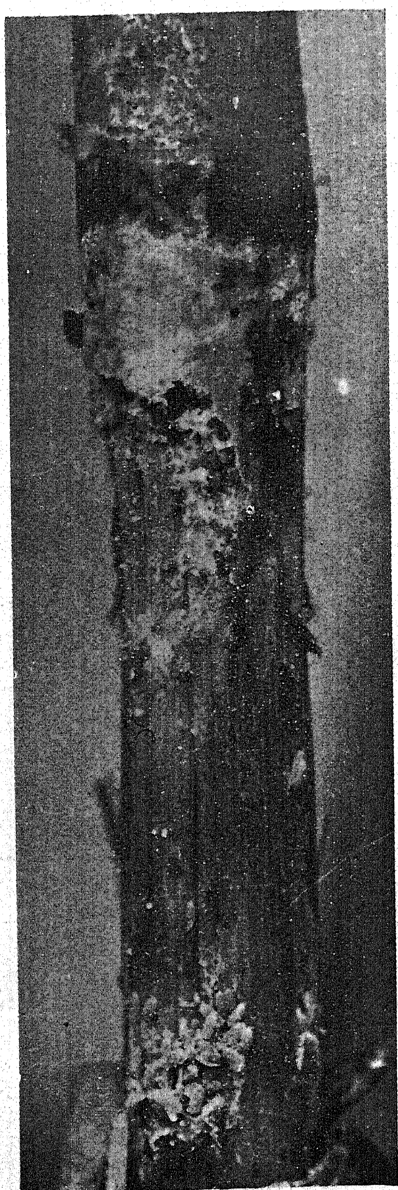

FIG. 4.

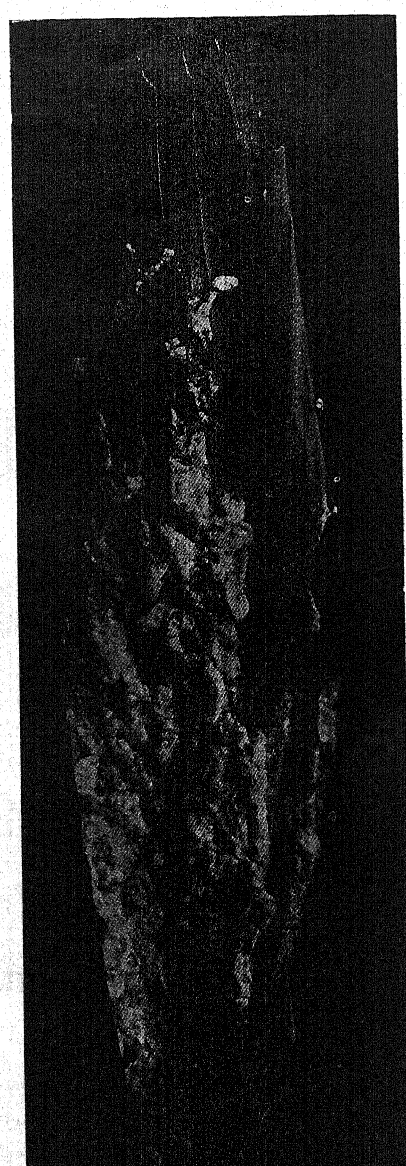

FIG. 5.

FIG. 4. A portion of sugarcane stem showing nodes infected by *S. sacchari*.
FIG. 5. A portion of sugarcane leaf showing infestation by *P. saccharifolii*.

sacchari and *Pseudococcus saccharifolii* which so long have been regarded as synonyms of a single species, do not appear to be so, as will be evident from the foregoing discussions, a summary of which is given in Table II below. Morphological studies of these species are also in progress.

TABLE II

Characters*	*S. sacchari*	*P. saccharifolii*
Colour and size ..	Pink; about 5 mm.	Yellowish; about 4 mm.
Nature of attack ..	Nodes of sugarcane beneath the leaf sheath (Fig. 4)	Sugarcane leaf (Fig. 5).
Biological difference ..	Eggs are laid in concealed ovisac beneath the abdomen. Incubation period of egg is less than 8 hours and the total life cycle is completed in about 20 days during August.	Eggs are laid in elongated ovisac protruding behind the body. Incubation period of egg is 5 to 6 days and the total life cycle is completed in about 26 to 28 days during August.
Antenna	0·276 mm. long, 7-segmented (Fig. 2a)	0·483 mm. long, 8-segmented (Fig. 3a).
Loop of oral bristles ..	Span 0·69 mm. (Fig. 2b)	Span 0·12 mm. (Fig. 3b).
Leg	0·534 mm. Not hairy. (Fig. 2c)	0·966 mm. well-chitinized setae present (Fig. 3c).

*Characters studied under high magnification.

ACKNOWLEDGMENT

The author is grateful for facilities and encouragement receievd from Dr. C. Thakur, Director, Sugarcane Research Institute, Bihar, Pusa. Sincere thanks are due to Shri A. R. Prasad, Assistant Entomologist, Sugarcane Research Institute, Bihar, Pusa under whose supervision the work was conducted and the authorities of Commonwealth Institute of Entomology, London for identifying the specimens.

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CLASSIFICATION OF SOILS IN THE PHAGWARA FACTORY ZONE IN THE PUNJAB

By

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(Sugarcane Research Station, Jullundur)

Introduction

A KNOWLEDGE of soils is essential for working out manurial and cultural schedules suiting different soil types. A reconnaissance soil survey in the Jagadhari factory area was reported earlier (Dass *et al.*, 1954). Five soil types were established in that zone. Similar studies were undertaken in the Punjab territory of the Phagwara factory zone and are described in the following pages. Marbut's system of soil classification (1928) was adopted in these studies.

This area comprising of 164 villages with a total cultivated area of about 96,200 acres receives an annual precipitation of 30 inches. The average maximum temperature for this area is 103·4° F. in summer and average minimum temperature 42·5° F. in winter. The general topography in most of the area is flat, except for the flood basin areas, where it is sloping to undulating.

Soils

The alluvial soils of the Phagwara factory area varying from sandy to silty clay loam in texture, have developed under semi-arid climatic conditions. The soils are alkaline in nature, containing moderate amounts of bases. These soils are greyish yellow to greyish brown in colour, while the soils of the riverine tract are greyish owing to the presence of free calcium carbonate.

Sixty-nine soil profiles up to a depth of 6 feet were opened at random for these studies. On the basis of the morphological characteristics of soil profiles *in situ* and physio-chemical analysis of different horizons and surface samples, the soils were classified into the following categories:—

Type I: These soils are met with in the vicinity of the river Sutlej, the area is subjected to flooding during the rainy months. These young soils are light grey in colour with variable surface texture. The morphological characteristics of a typical profile and physico-chemical analysis of the profile samples are given as under and in Table I (page 185):—

Morphological characteristics

(Village Burj Pukhta, Type I/sandy loam)

Depth	*Morphological characteristics*
0–8″	Greyish; sandy loam; moderately compact; easy to work; brisk effervescence with HCl.
8″–12″	Greyish; loamy sand; loose; roots and insect holes present; profuse reaction with HCl.
12″–21″	Greyish; loamy sand; moderately compact; roots and insect holes present; brisk effervescence with HCl.
21″–25″	Greyish yellow; sandy loam; moderately compact; roots scanty; profuse action with HCl.
25″–30″	Light grey; loamy sand; slightly compact, roots scanty; effervescence with HCl.
30″–33″	Greyish brown; sandy loam; moderately compact; slightly moist; effervescence with HCl.
33″–38″	Light grey; loamy sand; slightly compact; moist, effervescence with HCl.
38″–50″	Brownish yellow; silt loam; compact; moist; effervescence with HCl.
50″–63″	Greyish yellow; sandy loam; compact; moist; effervescence with HCl.
63″–72″	Greyish brown; silt loam; compact; moist, effervescence with HCl.

These soils are immature, hydrological and orographical factors having not played any effective role in their development. Free calcium carbonate in the powdered form is present throughout the solum. The

soils are alkaline in nature, poor in organic matter and total nitrogen contents, but have higher moisture-retaining properties as evidenced by the moisture-holding capacity values. These soils occupy about 5·5 per cent of the total cultivated area in this zone.

Type II: These soils occupy the major portion of the cultivated area in the factory zone and are generally greyish yellow or brown in colour. The morphological characteristics and physico-chemical analysis of a typical profile are given below and in Table I:—

TABLE I

Physico-chemical analysis:—Village—Burj Pukhta, type II/sandy loam

	0-8″	8-12″	12″-21″	21″-25″	25″-30″	30″-33″	33″-34″	38″-50″	50″-63″	63″-72″
	(Percentages on air-dry basis)									
Clay	11·05	4·65	5·30	11·35	4·60	10·15	5·95	17·15	21·3	10·00
Silt	25·80	11·80	13·74	25·05	11·45	24·80	13·05	51·93	19·13	58·86
Sand	63·15	83·55	80·95	63·60	84·95	65·05	81·00	31·92	59·57	31·14
Ionizable salts	0·134	0·081	0·099	0·194	0·074	0·093	0·087	0·191	0·172	0·125
Calcium carbonate	1·34	1·09	2·02	1·31	1·73	1·80	1·96	3·08	2·33	2·52
Organic carbon	0·48	0·192	0·223	0·234	0·180	0·210	0·132	0·27	0·27	0·336
pH	8·60	8·20	8·20	8·10	8·40	8·30	8·30	8·10	8·10	8·10
Water holding capacity	44·3	43·2	45·62	48·75	47·05	46·35	41·90	58·86	55·85	53·60
Sticky point moisture	24·53	Sand	Sand	25·75	Sand	32·40	Sand	35·22	29·72	23·50
Moisture equivalent	31·26	26·80	28·91	27·26	25·36	28·85	36·80	41·90	40·00	38·60
Total nitrogen	0·07	0·03	0·03	0·04	0·02	0·03	0·019	0·043	0·043	0·043
Total P_2O_5	0·163	0·200	0·169	0·169	0·176	0·154	0·161	0·166	0·154	0·153
Total K_2O	0·589	0·499	0·593	0·642	0·734	0·780	0·655	0·842	0·830	0·825
C/N ratio	6·07	5·48	6·33	5·44	9·00	6·02	6·94	6·28	6·28	7·81
Available Nitrogen (P.P.M.) ..	1·0	0·33	2·0	25·0	0·37	0·37	4·0	4·0	1·5	4·0
Available phosphate (P.P.M.) ..	..	..	..	..	..	..	..	..	..	..

Morphological characteristics

(Village—Burj Kandhari, Type II/sandy loam)

Depth	*Description*
0- 8″	Greyish brown; sandy loam; compact; moisture low; roots and insect holes present; slight effervescence with HCl.
8″–27″	Dull greyish brown; silty clay loam; hard and compact; low moisture and no action with HCl.
27″–38″	Greyish yellow; silty clay loam; hard and compact; low moisture and slight effervescence with HCl.
38″–45″	Greyish yellow; clayey; hard and compact; medium moisture; calcium carbonate concretions in abundance; small sized iron nodules and effervescence with HCl.
45″–57″	Greyish yellow; clayey; hard and compact; medium moisture; no effervescence with HCl.
57″–72″	Light greyish yellow; sandy loam; compact; medium moisture; calcium carbonate concretions and effervescence with HCl.

TABLE II

Physico-chemical analysis:—village—Burj Kandhari Type II/sandy loam

	0-8″	8″-27″	27″-38″	38″-45″	45″-57″	57″-72″
	(Percentages on air-dry basis)					
Clay	18·64	28·95	25·50	37·25	36·10	25·75
Silt	29·01	34·65	33·80	28·75	36·00	23·20
Sand	52·35	36·40	41·30	34·00	27·90	51·05
Ionizable salts	0·170	0·277	0·304	0·339	0·298	0·396
Calcium carbonate	0·247	..	..	0·157	..	0·421
Organic carbon	0·48	0·275	0·177	0·152	0·140	0·079
pH	8·05	8·88	8·90	8·85	8·75	9·30
Water holding capacity	42·23	49·30	46·83	51·50	46·51	41·00
Sticky point moisture	19·33	23·60	20·53	23·24	23·42	22·16
Moisture equivalent	33·64	36·48	39·20	47·60	40·67	42·85
Total nitrogen	0·074	0·051	0·039	0·035	0·032	0·028
Total calcium (CaO)	0·784	1·20	0·756	0·396	0·784	0·588
Total P_2O_5	0·194	0·092	0·084	0·107	0·098	0·132
Total K_2O	0·93	0·290	0·97	0·332	1·600	0·585
C/N ratio	6·51	5·38	4·51	4·34	4·34	2·82

The presence of an illuviated horizon of calcium carbonate concretions within six feet depth of the profile characterises these soils. The leaching down of the finer soil fractions up to fourth horizon is also evident. These soils are also low in organic matter and total nitrogen contents and their percentage decrease with the depth of the solum. The water-holding capacity, moisture equivalent and sticky point moisture values associated with the colloidal contents of the soil vary with the soil texture and register an increase up to the fourth horizon. These soils are of medium fertility and occupy the largest area i.e. about 60 per cent of the cultivated areas, in this zone.

Type III: The soils under this category are greyish brown in colour and have been subjected to more leaching as compared to type II soils. The morphological characteristics of profiles *in situ* and physico-chemical analysis of profile soil samples are given as under and in Table III:—

Morphological characteristics

(Village Sang Dhesian, Type III/sandy loam)

Depth	*Morphological description*
0–12″	Greyish brown; sandy loam; loose; easy to work; nut-like iron concretions; low moisture; effervescence with HCl.
12″–32″	Dark greyish brown; clayey; hard and compact; low moisture; nut-like concretions, small saline spots also present; no action with HCl.
32″–46″	Greyish yellow; clayey; hard and cloddy; medium moisture; no action with HCl.
46″–72″	Greyish yellow; clayey; hard and compact; medium moisture; no action with HCl.

TABLE III
Physico-chemical analysis, village Sang Dhesian, Type III/sandy loam

	8″-12″	12″-32″	32″-46″	46″-72″
	(Percentages on	air-dry basis)		
Clay	15·45	31·80	35·20	32·75
Silt	29·10	30·45	33·50	28·95
Sand	55·45	37·75	31·30	38·30
Ionizable salts	0·114	0·214	0·237	0·205
Calcium carbonate	0·485	..	..	..
Organic carbon	0·327	0·366	0·372	0·266
pH	8·10	7·60	7·60	7·00
Water-holding capacity	39·69	47·37	51·50	45·25
Sticky point moisture	33·30	36·90	36·70	35·50
Moisture equivalent	22·68	25·13	28·51	22·82
Total nitrogen	0·055	0·057	0·052	0·033
Total CaO	1·70	0·60	0·896	0·364
Total P_2O_5	0·256	0·210	0·139	0·160
Total K_2O	0·138	0·850	1·32	0·747
C/N ratio	5·91	6·37	8·30	7·98

These soils are well-drained and are characterised by the presence of an illuviated horizon having nut-like ferro-manganesian concretions. No zonation in respect of calcium carbonate is present in any of the horizons up to the sixth foot. The clay and silt fractions show an increase with the depth of the profile up to the third horizon, the uppermost horizon being light (sandy loam to loam) in texture. The pH value decreased with the depth of the profile and it varies from 8·1 to 7·00 as the depth increases. The soils are generally low in organic matter, total nitrogen and ionizable salt contents. Single value constants vary with the soil texture and register regular increase up to the third horizon.

Crop-cutting Experiments

Over 100 crop-cutting experiments were conducted at random in the three soil types in order to assess the performance of different cane varieties on the different soil types as also to acquire knowledge about the potential fertility of soils in this factory area. A total area of 1/20th of acre was harvested from each plot. The cane samples from the experimental crop were also analysed for their juice quality (Tables IV and V).

TABLE IV
Yield in mds. per acre

Cane variety	Type I	Type II	Type III
Co.L. 9 (Plant)	663·02(2)	646·0(5)	696·2(19)
Co.L. 9 (Ratoon)	683·6(3)	712·66(20)	711·70(6)
Co. 312 (Plant)	549·9(3)	735·47(13)	710·0(11)
Co. 312 (Ratoon)	..	636·2(19)	692·9(7)
Co. 285	555·5(2)	604·4(3)	608·6(3)
Average yield	592·56	656·52	669·83

Figures in parenthesis show the number of experiments.

TABLE V

Juice analysis

Soil type	Cane variety	Average total solids %	Average sucrose %	Average purity coefficient
I	Co.L. 9 ..	19·50	15·80	82·2
	Co. 312 ..	17·60	14·50	82·10
II	Co. L. 9 ..	18·90	15·35	84·2
	Co. 312 ..	16·92	14·34	84·2
	Co. 285 ..	18·30	15·20	83·10
III	Co. L. 9 ..	18·10	15·03	82·90
	Co. 312 ..	18·85	15·45	81·95

From the foregoing tables, it will be clear that the cane yields on an average were lowest on Type I soils, being almost equal on type II and type III soils. Amongst the three cane varieties, the performance of Co. L.9 on type I soil was better than the varieties Co. 312, and Co. 285; Co. L. 9 and Co. 312 showed equally good yeilds on Type II soils.

Best cane quality was recorded in the case of Co.L. 9 on all the three soil types, followed by Co. 285 and Co. 312; indicating that Co. L. 9 is an all-round good variety amongst the three cane varieties i.e. Co.L. 9, Co. 312 and Co. 285 for this factory zone.

SUMMARY

1. The alluvial soils of the Phagwara factory zone in the Punjab were classified into three main categories on the basis of the maturity of the alluvial deposits according to the Genetic System of soil classification.

2. The results of a number of crop-cutting experiments indicate the potential fertility of the soils in the order type III—type II—Type I. Out of the three cane varieties i.e. Co.L. 9, Co. 312 and Co. 285, mainly cultivated in this area, Co.L. 9 suited the different soil types better than other varieties both in regard to yield and quality.

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THE SOILS OF ROHANAKALAN ZONE OF MUZAFFARNAGAR DISTRICT, U.P.

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THE soils of Amritsar Sugar Mills Ltd., zone Rohanakalan, Muzaffarnagar, U.P., were studied with a view to classifying them according to their inherent characteristics and their relation to sugarcane cultivation. The work involved the study of soils of 63 villages covering an area of about 77,692 acres.

General Description of the Area

Location: The Rohanakalan factory is situated towards the north at a distance of eight miles from Muzaffarnagar. The district as a whole is roughly rectangular in shape lying between north latitude 29° 11′ and 29°45′ 15″ and east longitude 77° 3′ 45″ and 78° 7′. The average annual rainfall is 32′5″.

The two rivers viz. Hindan and Kali play an important role in the alignment of soils of Rohanakalan zone. The river Hindan forms the western boundary of the zone and the river Kali flows almost centrally from north to south with a semi-circular curve towards the west. The most prominent physical feature of the entire zone is the presence of sandy ridges which occur in belts of hillocks and occasional transverse ridges.

Methods of Analysis and Survey

Soil profiles representing the entire zone were studied *in situ* up to the depth of 6′ from the surface or up to the ground water-table if above 6′. The soil samples, horizonwise, were ground and passed through 2·0 mm. sieve for analysis in the laboratory. Mechanical analysis was carried out by the International pipette method, water-holding capacity with the help of keen-Raczkowski boxes, exchangeable bases by the method of Williams, Sigmound and Iyengar, pH values by glass electrode, organic carbon by Walkleys method, total nitrogen by Kjeldahls method and analysis of HCl extract by the method of A.E.A.

The soil survey work was carried out taking the village as unit. The soil boundaries were demarcated, while traversing the area, by colour, texture and topography and marked on the village maps. Soil profiles were studied at representative sites.

Data and Discussion

On the basis of intensive field as well as laboratory studies the soils of the zone have been classified into three main soil types viz. Type I, Type III and Type IV. These soil types have been sub-divided into textural sub-types depending on the texture of the surface as well as the sub-soil into Type I sandy silty loam, Type III loamy sand and Type IV sandy loam, Type IV loam and Type IV clay loam. The differentiating characteristics of these soils have been based on topography and morphological, physical, physico-chemical and chemical properties. Type I soils have been found in the low-lying flood-basin areas of the rivers. These are rich in calcium and have recent silt depositions. Type III soils are met with mostly on sandy ridges of pronounced freely-drained nature throughout the profile. Type IV soils represent uplands, located in between sandy ridges. These are mature soils. Topography has played an important role in development of these soils. Type III and Type IV soils cover the major area of the zone and are important from the cane cultivation point of view. The morphological characteristics and the analytical data of the representative soil profiles are given in Tables I to IV.

Type I: These soils are situated on the left bank of the river Hindan, both banks of the river Kali and along both banks of the *nala* which forms a natural drainage channel of villages on either side of it. This soil type covers only a small area in narrow belt; so it has not been studied in much detail. A brief description of these soils is, however, given to indicate their characteristics. The soils on the left bank of river Hindan are mostly sandy to sandy loam with silty touch in texture. The colour is ashy grey. Calcium carbonate is found in amorphous as well as in finely nodulated form. The pH values of soils vary between 7·7 to 8·0. The soils in the flood-basin of river Kali are, in general, sandy in texture with silty touch and water-table is very near the surface. The soils are alkaline but pH values decrease with depth. The surface soils usually contain calcium carbonate, both in amorphous as well as nodulated form, while the sub-soils are devoid of it.

Type III: There are a number of sandy ridges, narrow and wide, all over the zone. East of Type I belt of the river Hindan, there is a rise in the general level of land and at the top is found this soil type, locally known as ' bhur '. This soil is again met with in the east of the flood-basin of the *nala* in a narrow belt running parallel to the course of the *nala*. Another belt of Type III soils runs north to south almost parallel to the course of the river Kali. The morphological characteristics and the analytical data of a representative profile of this soil type are given in Table I.

TABLE I

Showing morphological characteristics and analytical data of a Type III loamy sand soil profile (village—Sissona)

Depth	Description
0″-7″	Brownish, more brown when wet; loamy sand; clods unstable in water; no effervescence with HCl; neutral with B.T.B.
7″-27″	Brown, reddish-brown when wet; loamy sand; shining mica; no effervescence with HCl; slightly acidic with B.T.B.
27″-58″	Deep brown, reddish-brown when wet; loam; cloddy; no effervescence with HCl; slightly acidic with B.T.B.
58″-72″	Brownish-yellow, deep brown when wet; loam; micaceous; no effervescence with HCl; slightly acidic with B.T.B.

ANALYTICAL DATA

	DEPTH			
	0″-7″	7″-27″	27″-58″	58″-72″
(a) *Mechanical (air-dry basis)*				
Coarse sand per cent	25·25	18·42	3·95	6·03
Fine sand per cent	47·49	51·69	50·06	51·95
Silt per cent	14·20	14·60	20·90	19·21
Clay per cent	10·50	12·80	23·20	21·48
(b) *Physical and physico-chemical (air-dry basis)*				
Water-holding capacity per cent	33·63	40·64	39·88	37·80
Moisture equivalent per cent	13·36	12·17	10·09	13 25
Sticky point moisture per cent	16·43	20·44	21·60	20·03
pH	7·0	6·8	6·8	6·8
Total exchangeable bases m.e. per cent ..	10·8	14·0	17·0	12·8
Exchangeable Ca.m.e. per cent	8·4	11·2	14·0	9·2
(c) *Chemical (air-dry basis)*				
Moisture per cent	0·22	0·36	0·50	0·42
Loss on ignition per cent	2·56	3·63	5·12	4·38
HCl insolubles per cent	90·87	83·70	80·24	84·39
R_2O_3 per cent	5·50	9·89	12·49	10·84
Al_2O_3 per cent	2·22	4·22	5·15	5·01
Fe_2O_3 per cent	3·28	5·67	7·34	5·83
CaO per cent	0·49	0·43	0·59	0·63
MgO per cent..	0·67	1·21	1·82	1·17
CaO/MgO	0·73	0·36	0·32	0·54
K_2O per cent	0·22	0·30	0·49	0·25
P_2O_5 per cent	0·020	0·066	0·032	0·049
Nitrogen per cent	0·027	0·071	0·080	0·028
Organic carbon per cent	0·60	0·40	0·36	0·30
C/N	22·2	5·6	4·5	10·7

The morphological descriptions and the analytical data of the profile studied above indicate that the soils belong to Type III loamy sand of sandy ridges. The colour of the soils is brownish to reddish-brown with yellowish tinge throughout. There has been illuviation of clay and sesquioxides in the third and fourth horizons. Water-holding capacity of the soil is moderate to low. The soil tends to be acidic in the lower horizons. Total base exchange status is also moderate with high calcium saturation. Total calcium status is normal, which if further leached, may affect the exchange complex. Total magnesium is, in almost all the horizons, more than calcium—which indicates the leaching has already affected calcium to some extent, which is confirmed by the illuviation of calcium and magnesium in the 3rd and 4th horizons. The soils seem to be poor in organic matter, nitrogen and phosphates but potash status is moderate. These soils need careful soil management viz. checking of soil erosion, improving fertility level and avoiding application of high doses of sulphate of ammonia etc.

Type IV: Outside the sandy tracts, towards the slope, the soils change in texture from Type IV sandy loam to Type IV clay loam. Type IV clay loam soils have been met within depressions only in patches lying in Type IV loam tracts. These are uplands, in general. The morphological characteristics and the analytical data of each sub-type are given in Tables II to IV.

TABLE II

Showing morphological characteristics and the analytical data of a Type IV sandy loam soil profile (village Rohana Khurd)

Depth	Description
0″-7″	Brownish grey, darkens when wet; sandy loam; clods unstable in water; no effervescence with HCl; alkaline with B.T.B.
7″-13″	Yellowish-brown, more brown when wet; sandy loam; micaceous, no effervescence with HCl; alkaline with B.T.B.
13″-27″	Brown, deep brown when wet; loam; cloddy; no effervescence with HCl; neutral with B.T.B.
27″-64″	Deep brown, reddish-brown when wet; loam; cloddy; some dark iron concretions, micaceous; no effervescence with HCl; neutral with B.T.B.
64″-72″	Yellowish-brown, deep brown when wet; sandy loam; micaceous; no effervescence with HCl; neutral with B.T.B.

ANALYTICAL DATA

	DEPTH				
	0″-7″	7″-13″	13″-27″	27″-64″	64″-72″
(a) *Mechanical (air-dry basis)*					
Coarse sand per cent	3·67	8·12	5·17	4·71	8·81
Fine sand per cent	53·19	56·86	45·15	49·93	58·80
Silt per cent	24·85	17·80	15·55	13·70	11·40
Clay per cent	14·85	15·30	27·85	27·70	19·00
(b) *Physical and physico-chemical (air-dry basis)*					
Water-holding capacity per cent	43·04	36·35	36·54	37·52	41·68
Moisture equivalent per cent	27·21	19·61	22·24	23·72	20·64
Sticky point moisture per cent	22·07	18·47	19·72	20·13	21·16
pH	7·8	7·5	7·1	7·0	7·0
Total exchangeable bases m.e. per cent	26·0	15·6	18·8	18·4	18·0
Exchangeable Ca.m.e. per cent	17·6	7·6	9·2	9·2	7·2

TABLE II—(*Contd.*)

ANALYTICAL DATA—(*Contd.*)

	DEPTH				
	0″–7″	7″–13″	13″–27″	27″–64″	64″–72″
(c) *Chemical (air-dry basis)*					
Moisture per cent	0·80	0·52	1·00	1·05	0·89
Loss on ignition per cent	3·60	2·64	3·94	3·81	3·76
HCl unsolubles per cent	86·74	89·09	83·27	81·21	83·97
R_2O_3 per cent	13·19	6·93	10·01	11·32	9·73
Al_2O_3 per cent	10·24	3·66	4·90	6·61	4·54
Fe_2O_3 per cent	2·95	3·27	5·11	4·71	5·19
CaO per cent	0·81	0·49	0·48	0·53	0·49
MgO per cent	1·31	0·78	0·86	0·59	0·51
CaO/MgO	0·62	0·63	0·56	0·90	0·96
K_2O percent	0·25	0·25	0·25	0·28	0·29
P_2O_5 per cent	0·148	0·130	0·046	0·096	0·062
Nitrogen per cent	0·090	0·042	0·073	0·039	0·015
Organic carbon per cent	0·52	0·21	0·19	0·19	0·12
C/N	5·8	5·0	2·6	4·9	8·0

The colour of the soils is brown to reddish-brown having a yellowish tinge in the last horizon. There has been a marked illuviation of clay in the third and fourth horizons. Water-holding capacity of the soils is highest in the surface layer, which seems to be owing to fairly high organic matter. The soil is slightly alkaline in the first two horizons but the rest of the horizons are neutral in reaction. Total base exchange status is better than type III soils, with favourable calcium saturation in the exchange complex. The total calcium status decreases with the depth of the profile, while iron increases. These soils do not seem to be deficient in phosphates and potash content. Organic matter and nitrogen indicate that efforts have been made to improve the fertility of soils.

TABLE III

Showing morphological characteristics and analytical data of a type IV loam soil profile (Village Dehchand)

Depth	Description
0″-8″	Yellowish-grey, more grey when wet; loam; cloddy; many dark concretions; no effervescence with HCl; slightly acidic with B.T.B.
8″-19″	Brownish-yellow; more brown when wet; loam; some iron concretions, micaceous; no effervescence with HCl; neutral with B.T.B.
19″-36″	Yellowish-brown, more brown when wet; heavy loam; cloddy; many iron concretions; no effervescence with HCl; neutral with B.T.B.
36″-61″	Yellowish-brown, more brown when wet; reddish mottlings; heavy loam; angular; yellow cements; no effervescence with HCl; neutral with B.T.B.
61″ and below	Yellowish, yellowish-brown when wet; loam; cloddy; yellow cement; no effervescence with HCl; neutral with B.T.B.

TABLE III—(*Contd.*)

ANALYTICAL DATA

	DEPTH				
	0″-8″	8″-19″	19″-36″	36″-61″	61″-below
(a) *Mechanical* (*air-dry basis*)					
Coarse sand per cent	0·70	0·86	0·88	1·76	1·53
Fine sand per cent	52·15	52·10	38·95	40·77	46·77
Silt per cent	26·43	24·00	22·21	20·66	25·71
Clay per cent	18·90	21·23	32·62	31·35	22·12
(b) *Physical and physico-chemical* (*air-dry basis*)					
Water-holding capacity per cent	46·15	43·49	44·50	46·06	48·82
Moisture equivalent per cent	28·53	25·64	29·92	32·87	34·31
Sticky point moisture per cent	23·85	21·55	21·83	24·63	22·73
pH	6·8	7·0	7·0	7·0	7·0
Total exchangeable bases m.e. per cent	11·6	22·0	26·4	27·2	29·2
Exchangeable Ca. m.e. per cent	9·2	12·8	14·8	15·6	15·6
(c) *Chemical* (*air-dry basis*)					
Moisture per cent	0·69	0·73	1·54	1·91	1·59
Loss on ignition per cent	4·68	3·75	5·71	6·03	5·22
HCl insolubles per cent	83·14	84·13	86·12	84·76	86·15
R_2O_3 per cent	10·29	6·83	5·74	9·02	6·93
Al_2O_3 per cent	6·00	3·48	2·87	5·67	4·21
R_2O_3 per cent	4·29	3·35	2·87	3·35	2·72
CaO per cent	0·27	0·29	0·29	0·31	0·32
MgO per cent	0·44	0·43	0·38	0·54	0·56
CaO/MgO	0·61	0·67	0·76	0·56	0·58
K_2O per cent	0·26	0·40	0·30	0·17	0·15
P_2O_5 per cent	0·029	0·060	0·125	0·151	0·096
Nitrogen per cent	0·122	0·074	0·067	0·108	0·067
Organic carbon per cent	1·26	0·32	0·37	0·32	0·24
C/N	10·3	4·3	5·4	2·9	3·6

The soils vary in colour from yellowish-grey to yellowish-brown. Iron concretions are present throughout the profile, but much more in lower horizons. There are yellow cement spots in the lower horizons which show a progressive leaching of sesquioxides. There is a marked illuviation of clay in the second, third and fourth horizons. The surface layer is slightly acidic but all other horizons are neutral in reaction. Total exchangeable bases are fairly high and increase with depth. The exchangeable calcium saturation also increases with depth. The total calcium content is moderate. Total nitrogen and organic matter levels indicate that fertility status of the soil is quite satisfactory.

TABLE IV

Showing morphological characteristics and the analytical data of a Type IV clay loam soil profile. (Village Akhlora)

Depth	Description
0″-7″	Brownish grey, darkens when wet; loam; cloddy; clods partially stable in water; no effervescence with HCl; neutral with B.T.B.
7″-32″	Brown, deep brown to reddish-brown when wet; clay loam; angular, dark concretions; no effervescence with HCl; neutral with B.T.B.
32″-41″	Brown, deep brown when wet; clay loam; angular; brownish yellow cements; dark concretions, no effervescence with HCl; neutral with B.T.B.
41″-54″	Yellowish-brown, deep brown when wet; clay loam; angular; dark concretions; no effervescence with HCl; neutral with B.T.B.
54″-72″	Yellowish-brown, deep brown to reddish-brown when wet; loam; angular, no effervescence with HCl; neutral with B.T.B.

ANALYTICAL DATA

	DEPTH				
	0″-7″	7″-32″	32″-41″	41″-54″	54″-72″
(a) *Mechanical (air-dry basis)*					
Coarse sand per cent	1·00	0·58	3·11	0·59	0·29
Fine sand per cent	50·27	39·73	38·19	41·72	43·52
Silt per cent	26·08	31·39	27·70	24·02	26·29
Clay per cent	17·33	27·51	29·70	31·90	25·50
(b) *Physical and physico-chemical (air-dry basis)*					
Water-holding capacity per cent	41·48	39·96	42·20	44·32	45·51
Moisture equivalent per cent	20·82	23·79	25·97	26·12	25·15
Sticky point moisture per cent	20·94	21·27	24·30	27·99	27·24
pH	7·0	7·0	7·0	7·0	7·0
Total exchangeable bases m.e. per cent	14·4	16·0	18·8	18·4	19·6
Exchangeable calcium m.e. per cent	12·0	14·0	14·8	16·0	13·2
(c) *Chemical (air-dry basis)*					
Moisture per cent	0·63	1·01	1·22	1·23	0·93
Loss on ignition per cent	3·59	4·48	4·62	4·87	4·91
HCl insolubles per cent	83·19	78·61	72·39	74·57	77·08
R_2O_3 per cent	10·53	13·70	18·70	16·86	14·81
Al_2O_3 per cent	7·26	8·99	12·79	11·43	9·78
Fe_2O_3 per cent	3·27	4·71	5·91	5·43	5·03
CaO per cent	0·56	0·60	0·84	1·27	1·23
MgO per cent	0·57	0·88	0·90	0·99	0·80
CaO/MgO	0·98	0·68	0·93	1·28	1·54
K_2O per cent	0·50	0·12	0·22	0·20	0·15
P_2O_5 per cent	0·083	0·042	0·029	0·057	0·071
Nitrogen per cent	0·087	0·057	0·045	0·055	0·038
Organic carbon per cent	0·64	0·27	0·22	0·18	0·17
C/N	7·4	4·7	4·9	3·3	4·5

The colour of the soil is brownish-grey to yellowish brown. The surface layer is loam while the lower horizons are clay loam except the last horizon. Iron concretions are prominent from second to fourth horizons. There is a marked illuviation of clay up to the fourth horizons. The water-holding capacity and moisture equivalent also increase in the layers of clay illuviation. The reaction of the whole profile is neutral. Total exchangeable base status is fairly high with high calcium saturation in the exchange complex. The sesquioxides and iron follow the trend of silt plus clay. There has been a marked illuviation of calcium in fourth and fifth horizons. Magnesium is less than calcium in the first three horizons. These indicate that leaching has affected calcium status in the profile. The soil is not deficient in potash content, whereas there seem to be deficiency in organic matter, phosphate and nitrogen.

Manurial-cum-varietal Trials

With a view to study the response of nitrogenous and phosphatic fertilizers on important cane varieties in different soil types of Type IV soils and Type III soils, four such trials (3^3 confounded design with single replication) were laid out on cultivators' fields. The three varieties selected were Co. 650, Co.S. 245, and Co.S. 321. Nitrogen was applied in the form of ammonium sulphate at three levels viz. 0 lb., 60 lb. and 120 lb. per acre and phosphate in three doses viz. 0 lb., 40 lb. and 80 lb. per acre in different combinations.

Morphological characteristics and the analytical data of the soils of experimental plots have been given in Tables I to IV. The cane yields of the trials are summarised in Table V.

Table V

Results of varietal-cum-manurial trials (Rohanakalan zone)

Cane yield in mds. per acre

Sl. No.	Soil type	Village	Varieties			N per acre			P_2O_5 per acre			S.E.
			Co. 650	Co.S.245	Co.S.321	0 lb.	60 lb.	120 lb.	0 lb.	40 lb.	80 lb.	
1.	Type III loamy sand ..	Sissona	755·9	840·6	812·5	683·1	832·6	893·3	822·5	782·1	804·2	14·3
2.	Type IV sandy loam ..	Rohanakalan	579·8	594·2	559·4	495·1	605·7	632·7	583·7	564·8	585·0	15·4
3.	Type IV loam ..	Dehchand	633·8	742·4	749·6	616·9	728·9	780·0	710·7	683·4	731·7	13·4
4.	Type IV clay loam	Akhlore	977·6	1056·4	1112·1	992·8	1049·0	1104·3	1007·1	1060·8	1078·2	19·3

The data in Table V show that highest yield has been obtained with Co.S. 321 which has also been found the best yielder in Seohara zone, district Bijnor, in Type III and Type IV soils (freely drained soils). It has been further observed that maximum response has been found in all the soil types of Type III and Type IV. The maximum response of N per lb. has been in lighter soils viz. loamy sand, sandy loam and loam. There has been practically no significant response to phosphate application.

Summary

The soils of Rohanakalan zone have been classified into three main soil types viz. Type I, Type III and Type IV on the basis of detailed field and laboratory studies. These main soil types have been divided into sub-types depending on the texture of surface as well as sub-soil. These are Type I sandy silty loam, Type III loamy sand, Type IV sandy loam, Type IV loam and Type IV clay loam soils. Topography has played a predominant role in the development of the soils of this zone. Type III and Type IV soils cover the major area and are important from the cane cultivation point of view.

Co.S. 321 has given the maximum yield in Type III and Type IV soils. Maximum response of N per lb. has been obtained in lighter soils viz. Type III loamy sand, Type IV sandy loam and loam.

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A STUDY OF THE EFFECTS OF BULKY ORGANIC MANURE AND CHEMICAL FERTILISER TREATMENTS OF CANE ON *GUR* QUALITY

By

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Introduction

THE authors reported (1957) that manuring of sugarcane with organic concentrates (castor cake or groundnut cake) and chemical fertilisers (ammonium sulphate or ammonium sulphate nitrate) in combination with super-phosphate has similar effects on claribility criteria of juice as well as colour, composition and storage quality of *gur*, the apprehensions expressed in certain quarters, that the product of cane receiving artificials is poor in quality as compared to that of crop treated with organic manures thus appears to be baseless. Pursuant to this finding, experiments were undertaken with a view to comparing the effects of the bulky organic manure compost with those of ammonium sulphate as also of a mixture of the two (on 50:50 nitrogen basis), all in conjunction with single superphosphate. Results of these studies have been reported in the present paper.

Experimental

Cane material was drawn from a randomised block trial with 6 replications, involving the following treatments applied over a basal dressing of sunhemp green manure:—

A—Control (no manure).

B—Compost @ 60 lb. N per acre+Single superphosphate @ 75 lb. P_2O_5 per acre.

C—Compost @ 30 lb. N per acre +Ammonium sulphate @ 30 lb. N per acre+Single super phosphate @ 75 lb. P_2O_5 per acre.

D—Ammonium sulphate @ 60 lb. N per acre+Single super phosphate @ 75 lb. P_2O_5 per acre.

The plots were harvested after 13 months of planting and converted into *gur* under identical conditions of manufacture without the use of any clarificant (manufacturing four samples per day, one from each treatment). The products were analysed for Brix., Pol. Purity, Glucose, Colloids, Ash, acidity and colour and stored during monsoons in alkalthene-lined bags. At the end of the storage period they were examined for deterioration in quality.

Discussion of Results

Results obtained were similar to those reported (*loc. cit.*) in the case of oil cakes and chemical fertilisers. As will be seen from Table I, the treatments had no significant effect on the composition of products. No

Table I

Showing effects of compost and ammonium sulphate manuring of sugarcane on gur *quality*

Constituents	Treatments				S.E. Tr (mean)	C.D. @ 5%	Significance
	A	B	C	D			
Brix per cent	95·8	97·2	94·8	94·5	0·51	1·54	BA CD
Pol. per cent	78·8	82·0	77·6	78·6	1·06		Non-significant.
Purity per cent	82·4	84·1	83·5	83·3	0·98		,, ,,
Glucose per cent	2·58	2·22	2·26	2·38	0·258		,, ,,
Colloids per cent	4·57	4·32	4·42	5·01	0·29		,, ,,
Ash (sulphated)	4·63	4·52	4·44	4·65	0·158		,, ,,
Acidity m.e. per 100 gms. ..	7·67	8·67	7·73	7·60	0·29		,, ,,
Colour N/2 Sol.	126	103	90	97	8·2	24·8	AB DC

adverse effect of ammonium sulphate or ammonium sulphate plus compost was observed on the colour of *gur*. The only difference found was in the brix values of *gur* which is not likely to be due to manurial effects. It, therefore, appears that types of nitrogenous fertilisers and manures have no special effect of their own on the end-products. In these experiments, the nitrogenous manures and fertilisers having been supplied in combination with superphosphate, the harmful effects of nitrogen were moderated bringing the *gur* qualities of both manured and unmanured cane to the same level. The findings of Mohan Rao (1954) that ammonium sulphate manuring of sugarcane is associated with higher nonsugars, non-protein nitrogen, colloids and low phosphate in juice, yielding poorer quality of *gur* as compared to farmyard manure were based on experiments where the manures and fertilisers were applied without any phosphate. The superior quality of farm yard manure treated products may, therefore, be due partly to the extra amount of phosphate present in farm-yard manure.

As for the keeping quality of the products, it will be seen from Table II that in almost all cases deterioration under storage was of the same order. The treatments had no significant effect on storage quality as judged by colour or composition of the products, thus clearly bringing out that manuring of sugarcane with inorganic fertiliser induces no significant difference in colour, composition or storage quality of *gur* as compared to organic manure where both of them are applied in combination with phosphate.

TABLE II

Showing effects of manuring sugarcane with compost, ammonium sulphate and a mixture of the two (all in combination with superphosphate) on the storage quality of gur

Constituents examined	Treatments A	B	C	D	Standard error of Treat. (mean)	Statistical significance
1. Brix per cent	96·9	96·6	98·0	98·0	0·48	Non-significant.
2. Pol. per cent	71·7	72·6	72·7	73·5	1·23	„ „
3. Purity per cent	74·0	75·2	75·2	75·0	1·22	„ „
4. Glucose per cent	4·03	3·23	5·46	3·32	0·590	„ „
5. Colour (N/2 Solution)	100	95	82	93	9·1	„ „

SUMMARY

(1) Samples of *gur* manufactured from canes receiving compost, ammonium sulphate and a mixture of the two, all in combination with superphosphate, were examined for their colour, composition and storage quality. The results were compared against no manure treatment.

(2) Manuring of sugarcane with compost, ammonium sulphate or a mixture of the two, all in combination with superphosphate was found to have similar effects on *gur* quality. The storage quality of the products was also unaffected by manurial treatments.

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SUGARCANE RUST IN BOMBAY STATE

By

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TILL recently rust disease of sugarcane had never become a limiting factor in the distribution of a new variety anywhere. With the serious outbreak of rust on Co. 475; however, during September-October 1949, the disease took on major importance in Bombay State. Owing to the susceptibility of this variety to rust as well as to smut diseases, Co. 475, was ultimately withdrawn on departmental recommendations.

Martin (1950) has recorded the occurrence of the disease in Australia, China, Fiji, Formosa, India, Indo-china, Japan, Java, the Phillipines and the Union of South Africa. Butler (1918) observed for the first time the telial stage of the fungus on *S. spontaneum* (a wild species). The findings of Patel *et al.* (1950) indicating the presence of both the uredo as well as teleuto—stages of Puccinia on Co. 475 of *S. officinarum* is significant. Since then the authors have come across several varieties affected by rust and having both the above stages of *Puccinia* on them.

The paper presents some salient observations on the progress of rust disease since its first occurrence in Bombay State. Its effect on the cane yields and its impact on promising cane varieties are briefly summarised.

Survey

Preliminary information regarding the prevalence of the disease, the acreage affected and the yields secured by progressive cultivators in the Bombay State during the five years preceeding 1954 were obtained by issuing a questionnaire to them. This was followed by a general survey of the rust-affected areas for evaluating incidence of the disease and the extent of damage caused by it. The effect of irrigation, manurial dose, spacing between rows, humidity of the tract etc., were also considered. The extent of infection was evaluated with reference to an enlarged Cobbs' chart for wheat rust with similar notings. The data are presented in Table I.

Distribution and Extent of Damage

The percentage incidence of rust during the survey was observed to be higher in Karad, Kolhapur, and Belgaum districts viz., in the heavy rainfall tract (humidity in season varying between 70 to 90 per cent) as compared to the incidence of that disease in Baramati, Poona, Belavandi, Shrirampur, Deolali-pravara and Kopergaon. In general, Co. 475 was susceptible both in the seedling stage as well as in mature stage to a lesser or greater extent. Although the damage caused to the leaf surface may not kill the cane, it is expected that a severe attack of the kind will certainly reduce the normal physiological functions of the plant that result in the formation and storage of sucrose.

From the data on yields of Co. 475 secured by over one hundred individuals, it was not possible to accurately determine the losses due to rust alone, taking the Padegaon yields or the local yields as standards for comparison; the obvious difficulties in such an estimation being that sugarcane is grown under varying soil and climatic conditions. Besides, irrigational facilities and agronomic practices differ widely and it is even more likely that in the same field the yields may vary from year to year depending upon care and soil treatment. For these reasons it was not possible to arrive at any definite conclusion regarding losses.

Meteorological and Microclimatic Observations

In Bombay, the rust disease of sugarcane is known to make its appearance in July, is maximum between September-October and may persist up till February. During these months the diurnal temperature variations, inside the crop of Co. 475 at the height of four feet, lie between 82° to 85° F. and the percentage humidity varies between 70 to 90 per cent. Besides these factors, the rainfall, cloudiness in the weather, combined

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TABLE I

Acreage, incidence and yields of Co. 475 (1954-55)

Sl. No.	Location	Crop	Area under Co. 475 in 1954	Area of Co. 475 affected by rust	Incidence* On the Plant	Incidence* On the crop	Age of the crop at the time of observation	Area of Co. 475 harvested in 1954-55	Yield of Co. 475/ acre in 1954-55
					Per cent		Months		
1.	Padegaon A.R.S. ..	Ratoon	0–08	0–08	32	Cons.	11	0–08	35–46
		Adsali	..	..	..	..	..	..	..
		Plant	0–06	0–06	35	Med.	11	0–06	52–04
2.	North Satara	Ratoon	..	..	..	..	..	..	..
		Adsali	5–03	1–03 4–00	35 55	Med. Med.	8 8	1–03 4–00	Data not available.
		Plant	31–00	31–00	50	Med, cons.	8	31–00	
3.	Kolhapur	Ratoon	8–00	8–00	55	Cons.	13	8–00	38·5
		Adsali	..	..	..	..	..	..	..
		Plant	19–18	19–18	50	Med. cons.	12	19–18	40·6
4.	Belgaum	Ratoon	3–20	3–20	60	Cons.	8	3–20	26·5
		Adsali	..	..	..	..	..	..	..
		Plant	23–20	23–20	50–80	Cons.	9–12	23–20	39·7
5.	Poona (Baramati) ..	Ratoon	3–35	3–35	35	Med.	9–15	9–15	41·6
		Adsali	6–00	3–00	55	Cons.	4–16	3–00	52·5
		Plant	11–20	11–20	31	Sl-Med.	3–14	10–20	53·0
6.	Ahmednagar								
	(a) Belvandi ..	Ratoon	..	..	..	..	..	..	..
		Adsali	..	..	..	..	..	..	..
		Plant	14–20	6–20 8–00	25 55	Med. Med.	12 12	5–00 9–00	50–0 48·5
	(b) Kanhegaon ..	Ratoon	..	..	..	..	..	..	..
		Adsali	10–00	10–00	40	Med.	10	10–00	Data not available.
		Plant	..	..	..	..	..	..	..
	(c) Shrirampur ..	Ratoon	14–05	14–05	37·5	Med.	4–10	6–05	28·4
		Adsali	18–00	18–00	17	Sl.	4–16	6–35	58·5
		Plant	16–00	16–00	30	Med.	10	16–00	43·2
	(d) Deolali Pravara ..	Ratoon	..	..	..	..	..	..	..
		Adsali	17–25	17–25	22	Sl.	4–16	16–00	50–3
		Plant	2–00	2–00	35	Med.	15	2–00	Data not available.
	(e) Kopargaon ..	Ratoon	20–00	20–00	15–20	Sl.	12	20–00	37·3
		Adsali	20–00	20–00	40	Med.	5	..	..
		Plant	7–00	7–00	15	Sl.	12	7–00	45·0

NOTE.—
Cons. = Considerable. Med. = Medium. Sl. = Slight.
*The incidence of sugarcane rust was calculated with reference to enlarged Cobbs' Scale Chart for Wheat Rust disease.

with high wind velocities during those months make the conditions all the more favourable for the growth and dissemination of the fungus spores. The infectve uredospores appear to be adversely affected by high atmospheric temperatures and fall in humidity as is evidenced by the fact that rust infection is not much noticeable in the months of April and May. The microclimatic and meteorological observations taken at Padegaon in the year 1955 appear in Table II.

TABLE II

Bioclimatic observation at Padegaon Farm in 1955

Month	Time	Micro-climatic observations												Meteorological observations				
		Inside variety Co. 475						In the open						Rain-fall	Temperature		Wind Velocity Average	Cloud. No. of hours of bright sun-light. Avg.
		Surface		4 ft.		12 ft.		Surface		4 ft.		12 ft.			Max.	Min.		
		V.P.	H%	V.P.	H%	V.P.	H%	V.P.	H%	V.P.	H%	V.P.	H%					
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
January ..	A	10·7	78	10·0	72	9·7	70	9·5	84	9·0	78	8·9	76	..	83·3	51·5	1·07	9·12
	B	12·8	40	10·9	36	9·9	33	13·8	36	10·2	32	9·6	32	..				
February ..	A	9·1	62	8·7	61	8·2	57	8·4	62	7·6	53	7·4	51	..	91·9	54·9	2·40	10·22
	B	12·6	29	8·7	22	7·2	19	12·1	22	6·7	17	6·2	16					
March ..	A	12·0	66	11·1	62	10·6	59	10·0	61	9·5	58	9·3	57	1·09	96·7	59·2	2·99	10·00
	B	11·7	25	7·9	18	6·4	15	10·5	19	5·7	12	5·1	11					
April ..	A	12·5	67	11·7	61	11·1	58	11·4	62	10·3	56	10·1	55	0·26	97·3	60·0	7·12	10·64
	B	11·4	25	8·4	19	7·1	16	10·9	20	5·5	12	4·4	10					
May ..	A	20·5	77	11·5	73	18·9	72	19·6	72	18·3	71	17·5	69	0·65	102·0	75·2	7·24	8·04
	B	17·7	39	15·6	36	11·3	32	15·1	26	11·0	21	10·1	20					
June ..	A	21·1	84	20·1	82	19·4	79	20·1	77	18·1	74	17·7	73	0·37	93·2	71·7	9·36	9·91
	B	20·8	60	18·2	53	16·3	47	19·4	43	14·9	40	14·3	39					
July ..	A	20·5	94	20·2	93	19·9	92	19·6	85	18·4	84	18·1	83	1·90	85·0	70·5	5·20	4·48
	B	22·5	77	20·7	71	19·7	68	20·7	56	17·9	57	17·6	58					
August ..	A	20·2	93	19·6	92	19·0	91	19·1	87	18·1	85	17·7	84	4·12	82·6	70·5	6·54	2·81
	B	20·8	74	19·7	71	19·0	69	20·2	60	17·2	59	16·6	58					
September ..	A	19·9	94	19·1	92	18·4	91	18·9	91	17·8	89	17·3	87	8·94	86·2	68·4	5·79	7·21
	B	21·7	74	19·4	65	17·9	58	20·9	54	16·6	48	15·7	47					
October ..	A	18·6	97	18·1	96	17·8	95	18·0	95	17·3	94	16·9	92	8·04	84·7	66·5	2·85	8·24
	B	20·1	79	18·6	70	16·9	60	21·4	66	15·9	55	14·7	52					
November ..	A	10·1	92	9·7	91	9·4	89	9·4	91	8·8	88	8·6	88	..	82·7	47·4	1·45	8·44
	B	14·1	64	11·2	47	8·2	30	11·0	35	7·2	26	6·4	24					
December ..	A	10·6	94	10·4	93	10·0	90	9·8	92	9·2	89	9·1	88	..	82·1	49·3	1·18	9·66
	B	15·6	72	12·5	54	9·8	37	13·3	40	9·1	33	8·4	31					

NOTE.—
Location of Padegaon Farm: Latitude .. 18°12 N. Longitude: .. 74°10 E. Ht. above sea level .. 1,824 ft.
A:— Observations taken at 7.34 a.m. for microclimatic data.
B:— Observations taken at 2.34 p.m. for microlimatic data.
V.P.:— Vapour pressure in mm.
H%:— Humidity percentage.

VARIETAL SUSCEPTIBILITY

(a) Natural susceptibility to sugarcane rust has been encountered at Padegaon, on the following varieties: Co. Nos. 405, 619, 475, 678, 718, 785, 792, 915, 987, 990, 992, 993, 1019, 1022, 1025, 1106 and 1141.

(b) Susceptibility to rust under artificial condition was tested by spraying live uredospores of the fungus from Co. 475 on young plants grown in pots and kept under controlled conditions at optimal humidity. The infection took place on Co. Nos. 475, 684, 768, 798, 818, 911, 915 and 925. The varieties under test were Co. Nos. 419, 475, 649, 658, 678, 684, 685, 718, 740, 744, 759, 768, 771, 775, 783, 784, 785, 787, 792, 794, 798, 799, 800, 818, 911, 915 and Co. 925. It may be pointed out that, as stated earlier, Co. Nos. 678, 718, 787 and Co. 792 were susceptible to rust under natural conditions, but these however, did not take up the infection on artificial inoculation under controlled conditions with spores from Co. 475 variety. This

difference in susceptibility of cane varieties to rust has given an indication of the probable existence of physiological races of *Puccinia*. The phenomenon is being confirmed by detailed study. The varieties susceptible to rust along with their percentages and incidence of attack is given in Table III.

TABLE III

Varieties of sugarcane susceptible to rust, with their parentages and incidence of attack

Trials	Varieties Co. Nos.	Parentage	Susceptibility	Incidence: On the leaf (percent)	Incidence: On the crop	Spores of *Puccinia* encountered
Final varietal	Co. 678	Co. 603 × Co. 301	Natural	15%	Slight	Uredospores and teleutospores.
	475	(Co. 421 × Co. 440) × Co. 419	Natural and artificial	50%	Medium	,, ,, ,, ,,
	792	Co. 449 × (POJ. 2725 × Imperata Sp.)	Natural	25%	Medium	Uredospores
	718	POJ. 2878 × Co. 371	Natural	10%	Slight	Uredospores
	787	Co. 443 × Co. 453	Natural	10%	Slight	Uredospores
	684	POJ. 2878 × Fiji B.G.C.	Artificial		Trace	Uredospores
	798	Co. 603 × Co. 449	Artificial		Trace	Uredospores
Pre-final varietal	915	Co. 603 × (Co. 453 × POJ. 2878)	Natural and artificial	30%	Medium	Uredospores and teleutospores
	768	Co. 527 × (POJ. 2725 × Imperata sp.)	Artificial	12%	Medium	Uredospores and teleutospores
	911	Co. 603 × (POJ. 2725 × Imperata sp.)	Artificial	3%	Slight	Uredospores
	818	Co. 603 × EK. 28	Artificial	8%	Trace	Uredospores
Preliminary	985	Co. 475 × Co. 290	Natural	5–7%	Slight	Uredospores and teleutospores
Varietal	987	Co. 475 × Co. 290	Natural	10%	Slight	Uredospores
	990	Co. 475 × (POJ. 2725 derivative) 63/32	Natural	3%	Trace	Uredospores and teleutospores
	992	Co. 667 × POJ. 2961	Natural	40%	Medium	Uredospores and teleutospores
	993	Co. 678 × [(Vellai × Narenga), × Co. 205]$\frac{201}{1}$	Natural	20%	Slight	,, ,, ,, ,,
	1019	Co. 603 × Co. 449	Natural	60%	Considerable	,, ,, ,, ,,
	1022	Co. 449 × Co. 453	Natural	25%	Slight-medium	,, ,, ,, ,,
	1025	Co. 678 × P. 8331	Natural	25%	Medium	,, ,, ,, ,,
New arrivals	1106	Co. 527 × Co. 617	Natural	15%	Slight	,, ,, ,, ,,
	1141	Co. 603 × Co. 449	Natural	25%	Slight medium	,, ,, ,, ,,
Museum	405	B. 6308 × POJ. 2696	Natural	15%	Slight	,, ,, ,, ,,
	619	POJ. 2878 × Co. 312	Natural	8%	Trace	,, ,, ,, ,,

Alternate and Collateral Hosts

Attempts to find out the alternate and/or collateral hosts from among the weeds and grasses commonly found in rust-affected cane fields have not met with success. The search, however, continues. It is pertinent to mention here the probability that may exist in the perpetuation of rust disease from cane to cane especially since susceptible varieties may be found all the year round at different stages of cane growth.

Summary

Recurrence of rust disease of Sugarcane has been recorded year after year since its first occurrence in 1949. The presence of the uredo and the teleuto stage of *Puccinia* has frequently been encountered on several susceptible varieties. The difference in susceptibility of cane varieties to rust under natural conditions and when artificially inoculated by spraying a suspension of spores obtained from Co. 475 suggest the existence of possible physiological races in this species of *Puccinia*. Assessment of losses in cane yields due to rust could not be definitely determined owing to variations in factors like soil and climatic conditions, agronomic practices and irrigational facilities under which cane is grown in the Bombay Deccan.

Acknowledgment

The authors are indebted to the Plant Pathologist to Government, Bombay State, for helpful suggestions in the work.

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EFFECT OF ENDRIN ON THE INCIDENCE OF SUGARCANE LEAF HOPPERS (*PYRILLA PERPUSILLA* WALKER)

By

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INTRODUCTION

ENDRIN* ($C_{12}H_8Cl_6O$) a synthetic chlorinated hydrocarbon is derived from petroleum in the same way as Aldrin and Dieldrin, but has longer residual effect than these two. It is a stereo-isomer of Dieldrin which is the endo-exo isomer. It is a highly toxic organic compound and is used all over the world in controlling numerous pests of various economic crops.

The Government of Bhopal (1954) for the first time in India, conducted aerial spraying, using endrin to control *Pyrilla* in an area of 700 acres. One hundred per cent mortality of nymphs and adults was observed on the third and fourth day of the spraying respectively. Eggs, of course, remained unaffected in the leaf-sheaths, but on hatching the young nymphs died, due to the residual effect of the insecticide. Gupta and Avasthy (1954-56) while summarising the work done all over India, reported that spraying 0·1 lb. actual Endrin emulsion per acre has given very promising results against *Pyrilla*.

Large-scale trials were conducted in Bihar with a view to finding out the efficacy of the insecticide against *Pyrilla*.

MATERIAL AND METHOD

The field experiments were conducted at Motihari and Pusa where the infestation of *Pyrilla* was severe during the last two years in the January planted crop. 73·7 and 69·0 acres were sprayed at Motihari (third week of June, 1955) and Pusa estate (end of September) respectively. Eight ounces of Endrin 19·5 per cent Emulsifiable concentration (0·1 lb. actual) were used in 100 gallons of water per acre. The observations both pre-treatment and post-treatment (three weeks after spraying) were recorded by following the sampling technique as suggested by Khanna *et al.* (1950). A number of 1/40th acre ($60' \times 18'$) plots were selected at random. From each plot 15 per cent of the crop was examined in detail. This was done by examining three units each of three feet row length from each of the six rows, of the plot. In each unit all the leaves, both dry as well as green were counted and examined for the presence of number of egg-masses as also the number of eggs in each of those egg-masses. From this, percentage of affected leaves, average number of egg-masses per 100 leaves, average number of egg-masses per affected leaf and the average number of eggs per egg-mass were all calculated. The data thus collected were statistically analysed.

RESULTS AND DISCUSSION

The results achieved in Motihari area, where the experiment was conducted at four different centres, have been furnished in Table I.

TABLE I

Effect of Endrin on sugarcane leaf hoppers, Motihari, 1955-56

Sl. No.	Number of canes			Number of leaves			Percentage affected leaves	Total number of egg masses	Average number of egg masses per 100 leaves	Average number of egg masses per affected leaf	Average number of eggs per egg-mass
	Examined	Affected	Per cent affected	Dry	Green	Affected					
					(a) *Pre-treatment*						
1.	254	67	26·37	375	1928	122	5·29	465	20·19	3·81	36·02
2.	251	79	31·47	413	2075	139	5·59	420	16·88	3·02	37·01
3.	239	80	33·47	338	2022	138	5·84	520	22·04	3·77	36·02
4.	254	77	30·31	325	2120	132	5·39	389	15·91	2·95	34·59
					(b) *Post-treatment*						
1.	277	8	2·89	376	2002	13	0·55	22	0·92	1·69	20·26
2.	229	8	3·50	344	1844	10	0·46	19	0·87	1·90	18·38
3.	220	7	3·18	329	1773	10	0·48	17	0·81	1·70	17·75
4.	246	13	5·28	390	1987	14	0·59	28	1·18	2·00	19·30

*Endrin is 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octohydro-1, 4-endo-endo-5, 8-dimethanonaphthalene.

It will be seen that spraying with Endrin reduced the percentage of affected leaves from 5·84 to 5·29 before treatment to 0·50 to 0·46 after treatment, the mean reduction being 5·01 per cent. The average number of egg-masses per 100 leaves as also the average number per affected leaf, which ranged between 15·91-22·04 in the case of the former and 2·95-3·81 in case of the latter, were reduced to 0·81-1·18 and 1·69-2·00 respectively, the mean reduction in the two criteria being 15·75 and 1·57 respectively. Similarly the average number of eggs per egg-mass was also reduced from 34·59 to 37·01 in pre-treatment plots to 17·75 to 20·26 in post-treatment plots, the mean reduction being 16·99. All these reductions are statistically significant, as can be seen in Table II.

TABLE II

Statistical Summary

Criteria	Pre-treatment	Post-treatment	Mean decrease	S.E. (difference)	" t "
1. Percentage of affected leaves	5·33	0·52	5·01	±0·15	33·40**
2. Average number of egg-masses per 100 leaves	18·75	3·00	15·75	±2·06	7·65**
3. Average number of egg-masses per affected leaf	3·39	1·82	1·57	±0·31	5·06*
4. Average number of eggs per egg-mass ..	35·91	18·92	16·99	±0·85	19.92*

* Denotes significance at five per cent level. ** Denotes significance at one per cent level.

The results achieved at Pusa, where as many as 13 plots were kept under observation, are presented in Table III.

TABLE III

Effect of Endrin on Sugarcane Leaf hoppers, Pusa Estate, 1956-57

Sl. No. of plot	Number of canes			Number of leaves			Percentage of affected leaves	Total number of egg-masses	Average number of egg-masses per 100 leaves	Average number of egg-mass per affected leaf	Average number of eggs per egg-mass
	Examined	Affected	Percent age affected	Dry	Green	Affected					
					(a) *Pre-treatment*						
1.	114	35	30·7	554	1012	79	5·04	139	8·88	1·76	24·09
2.	108	25	23·1	620	1219	42	2·28	110	5·99	2·62	22·87
3.	108	35	32·4	544	872	76	5·37	148	10·45	1·95	18·46
4.	114	36	31·6	692	1296	56	2·81	143	7·19	2·55	21·28
5.	118	32	27·1	693	1301	50	2·50	119	5·97	2·38	22·31
6.	114	30	26·3	723	1277	47	.2·35	143	7·30	3·10	24·01
7.	102	47	46·1	527	1203	105	6·07	245	14·16	2·33	23·32
8.	109	51	46·8	543	1140	93	5·53	216	12·83	2·32	22·61
9.	110	38	34·5	774	1257	78	3·64	251	12·36	3·22	22·69
10.	101	33	32·7	630	1194	62	3·40	145	7·95	2·34	21·63
11.	106	55	51·9	504	1089	132	8·29	320	20·08	2·42	22·60
12.	97	38	39·2	667	1220	59	3·13	91	4·82	1·54	26·89
13.	124	49	39·5	496	920	52	3·62	86	6·07	1·65	19·94
					(b) *Post-treatment*						
1.	111	9	8·1	631	1256	11	0·58	27	1·43	2·45	21·29
2.	109	16	14·7	528	1073	16	1·00	20	1·25	1·25	15·90
3.	109	14	12·8	516	904	16	1·13	21	1·48	1·31	18·71
4.	117	19	16·2	586	1158	23	1·32	33	1·89	1·48	18·16
5.	120	12	10·0	694	1394	18	0·26	38	1·82	1·55	20·77
6.	126	12	9·5	744	1458	13	0·59	30	1·36	2·31	21·36
7.	164	12	7·3	973	1503	12	0·48	14	0·57	1·17	15·07
8.	82	17	20·7	1107	1813	17	0·58	23	0·78	1·35	12·04
9.	169	12	7·1	1071	1635	12	0·44	16	0·59	1·33	13·56
10.	106	9	8·5	510	920	11	0·77	17	1·19	1·54	18·06
11.	128	11	8·6	631	1111	12	0·69	17	0·97	1·42	18·28
12.	160	4	2·5	557	1066	3	0·18	5	0·31	1·66	13·00
13.	122	3	1·1	1018	1451	4	0·16	4	0·16	1·00	10·00

The observations recorded confirm the results obtained at Motihari, as can be seen in Table IV (Fig. 1).

FIG. 1.

Effect of Endrin on *Pyrilla.*

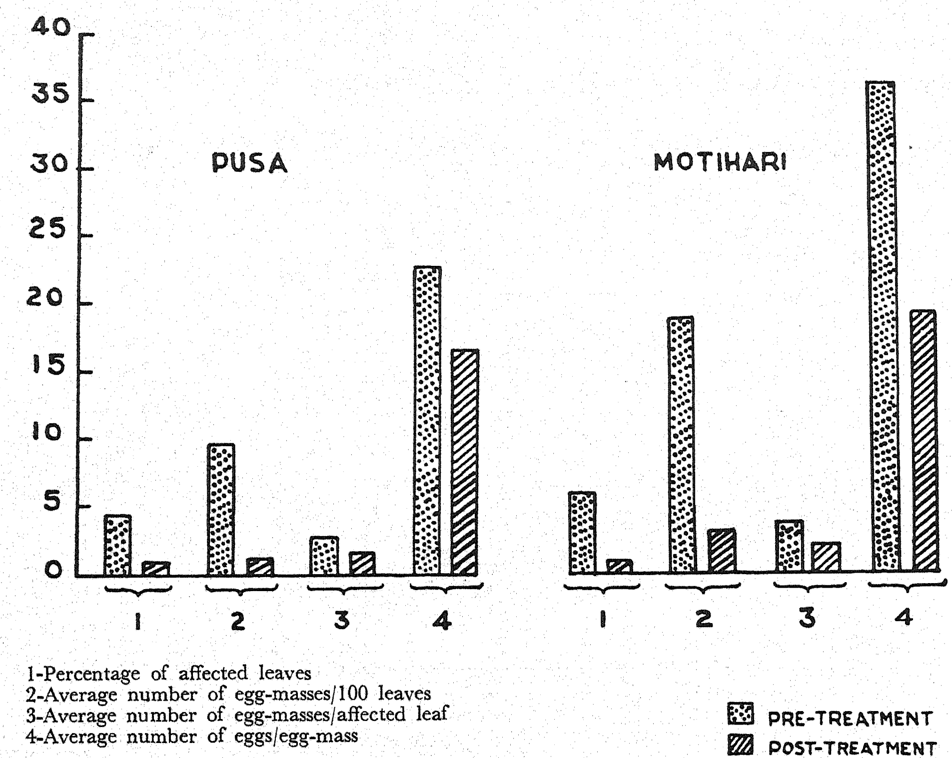

TABLE IV

Statistical Summary

Criteria	Pre-treatment	Post-treatment	Mean decrease	S.E. (diff.)	" t "
1. Percentage of affected leaves	4·18	0·63	3·55	±0·25	14·06**
2. Average number of egg-masses per 100 leaves	9·50	1·00	8·50	±1·42	5·99**
3. Average number of egg-masses per affected leaf	2·32	1·56	0·76	±0·18	4·19**
4. Average number of eggs per egg-mass ..	22·52	16·63	5·88	±1·36	4·33**

** Denotes significance at one per cent level.

These findings amply demonstrate the efficiency of Endrin in controlling sugarcane leaf hoppers.

SUMMARY

Endrin, a synthetic chlorinated hydrocarbon, is derived from petroleum and is extensively used all over the world in controlling numerous pests of various economic crops. Large-scale trials were conducted in Bihar with a view to finding out the efficacy of this insecticide against sugarcane leaf hoppers (*Pyrilla*). Spraying was done with 0·1 lb. actual Endrin emulsion per acre diluted in 100 gallons of water. Pre-treatment and post-treatment observations were recorded by selecting a number of 1/40 acre plots at random and examining 15 per cent crop from among these selected plots. The data were statistically analysed.

It was observed that (i) the percentage of affected leaves was reduced significantly from 4·49 to 0·61, (ii) the average number of egg-masses per 100 leaves as also per affected leaf were reduced significantly from

12·83 and 2·86 to 0·99 and 1·63 respectively and (iii) the average number of eggs per egg-mass was also reduced significantly from 33·23 to 18·67.

Endrin is a highly toxic insecticide and therefore calls for all precautions and care in handling.

ACKNOWLEDGMENTS

The author is greatly indebted to Sri K. L. Khanna, Director, Sugarcane Research and Development, Bihar, Pusa for his kind guidance and encouragement. Thanks are also due to the management of Shree Hanuman Sugar Mills Ltd., Motihari for very kindly providing all the facilities for conducting this work. The assistance rendered by the Mobile Unit Workers of the Entomological Section is also acknowledged. Sincere thanks are also due to Sri M. N. Alam for the statistical analysis.

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Research Notes

Reunion of Partially Broken Tops in Sugarcane

In the course of sampling sheaths from standing sugarcane (variety Co. 419) on this Station, the tops accidentally got severed on some occasions; and, in a few cases where the breakage was partial with the top still having connection with the stalk, these were left to stand on the respective canes instead of being removed. The breakage was noted to occur near the node of the stalk, resulting in a partial severance of the top, ranging from about one-half to three-fourths the diameter of the stalk at that point. The green top was noted to stand by itself in the socket formed by the close leaf-sheaths in that region. It was observed by one of us (R.L.N.), that the top got again connected to the main stem in due course, re-established itself and continued to grow normally (*vide* first set of canes in fig. 1). This phenomenon was noted to be most prominent in the case of breakage of tops occurring in the months of July and August of the 1956-57 season, and no less than two dozens of such plants were observed in an area of about an acre. This observation was again noted during the current season in the case of a number of plants. Reunion of stems and tops after partial breakage is a known phenomenon in dicots, but the authors have not come across reference to such an occurrence in monocots in general, and sugarcane in particular.

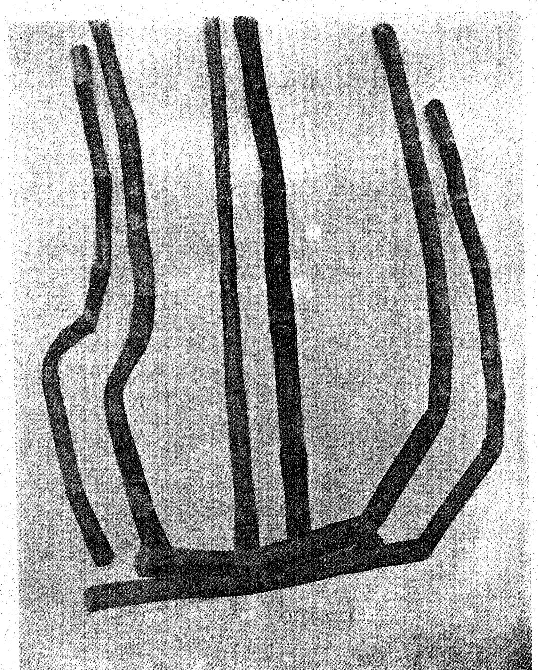

Fig. 1. Shortening of internodes in sugarcane following (each pair from left to right) physical injury to top, borer-attack, and lodging. (Variety: Co. 419).

One difference that was noted, however, was that there was a shortening of the internodes following this injury, indicating a stress on the plant to overcome the same, and a temporary retardation to growth (Fig. 1). Formation of shorter internodes in cane following a physiological shock like lodging, or an insect pest attack, etc., is a common observation. However, detailed information, besides this shortening of internodes, on the bio-chemical aspects of the plant during the process of its overcoming such a shock or injury, is meagre. Borden (1942), Srivastava (1935), Sen and Mallick (1952), and Narasimha Rao (1954) dealt with the influence of lodging on the physiology of the cane plant. Geerligs (1924) reported on the effects of cane borer, while Khanna and Chakravarti (1949) studied the changes brought about by an attack of

red-rot on the biochemical aspects of the plant. A general increase in the acidity and reducing sugars, with a fall in the sucrose in the juice was reported under the above conditions.

Further studies on this aspect with special reference to the anatomy of the stalk at the region of the breakage, and the bio-chemical changes taking place in the plant under such conditions of shock or injury, are contemplated.

The authors' thanks are due to the Indian Central Sugarcane Committee, New Delhi, for financing the scheme of research on sugarcane at this Station.—R. L. NARASIMHAM and N. V. MOHAN RAO, Sugarcane Research Station, Anakapalle, Andhra Pradesh.

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SOME OBSERVATIONS ON RED ROT DISEASE OF SUGARCANE IN PUNJAB

RED rot disease was first recorded in Punjab in 1925 in Ferozepur on chewing canes of noble type in an epidemic form, forcing the abandonment of the cultivation of local types. During 1934-39, it was recorded in a serious form on noble canes in certain villages of Amritsar and Karnal districts. In Amritsar, the disease was also observed on Co. 223 and Co. 285. Later on, during 1949-50 to 1952-53, Co. 312, Co. 313 and some other varieties were also found affected with this disease, in the villages of Karnal and Ambala districts, in the area of the Saraswati Sugar Mills, Yamuna Nagar. In 1953-54, it was further recorded doing considerable damage to Co. 312 and Co. 313 in some villages of the Ambala, Naraingarh and Jagadhri Tehsils of Ambala district and Sonepat Tehsil of Rohtak district. Later survey has also revealed the presence of this disease in a serious form in certain villages of Hoshiarpur and Jullundur districts.

In the selection of new varieties, special attention is also given at the Sugarcane Research Station, Jullundur, in assessing the resistance or susceptibility of the new sugarcane varieties to this disease. For this purpose, important varieties are artificially inoculated with the culture of the causal organism of this disease, and the behaviour of the different varieties is recorded. As a result of such trials, out of the varieties recommended for general cultivation, Co. 312 has been classed as highly susceptible, followed by Co.L. 29, Co. 313 and Co. 285. A few varieties, however, namely Co. 453, Co. 421 and Co. L. 9 have shown fairly high resistance to this disease. In fact, under field conditions, Co.L. 9 has not so far been found attacked by this disease anywhere in this State nor even in the area of the Saraswati Sugar Mills, Yamuna Nagar, where this disease was recorded in a serious form, a few years back. Co. 453 was found rarely attacked till recently but it has now also been affected by this disease at various places. Apparently, the indications are that the resistance of this variety has broken down now. Summing up, it may be said that of the varieties in cultivation in the State, Co. 312, Co. 313 have been found to be highly susceptible to this disease and Co. 453, Co.K. 30, Co. 421, Co. 285, and Co.L. 29 have also shown this disease in varying degrees in certain localities.—HARBANS SINGH, SARDUL SINGH and NAND SINGH, Sugarcane Research Station, Jullundur Cantt., Punjab.

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SCLEROTIAL RED SHEATH DISEASE OF SUGARCANE IN THE DECCAN

OUT of the eighty-four known sugarcane diseases in the world, Martin (1950) has listed seven with their causative agents, as affecting the leaf sheath of cane. Among these, the red rot of sheath and the "Cytospora sheath rot and stem canker" are the only ones reported to be present in India. In this paper a sclerotial disease of cane leaf sheath is described. The disease is endemic in the Deccan Canal regions and its epiphytotic nature was for the the first time recorded in November 1954 on the estates of Phaltan Sugar Works in North Satara. The entire 15-acre sugarcane plantation was severely damaged by the disease.

Symptoms: The affected sheaths are recognised by the blood-red dis-colouration of the collenchymatous and parenchymatous cells of the leaf sheath, visible on both surfaces. The fungus grows profusely under cool and humid weather on the inner surface of the sheath facing the stem. In severe cases the epidermal cells of the stem facing the reddened sheath are also attacked causing minute reddish scars and at times the eye-bud gets infected, the sheath reddening does not extend to the leaf blade but the margins of the leaves corresponding to the affected sheaths primarily exhibit unhealthy yellowing which subsequently progresses to cover more than half of the leaf-blade tissue, causing it to palor, dry and wither away. The withering of the leaves starts from the larger leaves below the crown, those at the apex remaining unaffected for some time. Besides destroying the chlorophyl content of the sheath *in vitro* the fungus is capable of hydrolysing starch, sucrose and glucose *in vitro.* The disease generally occurs on young plants (both mother-canes and tillers) resulting in unhealthy canes which are stunted and slender. In Bombay State the disease is predominantly found between the months of October and February when the cane is in its early growth stage. With the rise in temperatures and fall in humidity, the incidence too falls considerably and the partially-affected plants may be seen to recuperate from March onwards. In some cases, however, the damage is severe and permanent.

Varietal susceptibility: Besides Co. 419 which is widely grown in the Deccan, other promising varieties like Co. 678, Co. 718, Co. 740 and Co. 798 are susceptible to the sclerotial red sheath disease under natural conditions. The infection could be artificially produced on Jowar also.

The fungus: The fungus culture conforming to the genus sclerotium has been repeatedly isolated from affected tissue and the pathogenicity of the isolate has been confirmed under field experiments at Padegaon. The optimal temperature and humidity ranges for the occurrence of the disease, appear to be 84° to 90°F. and 90 to 100 per cent respectively. Sporulation in the fungus has not been observed. Sclerotial development takes place in about ten days on nutrient agar medium (pH 7) kept at 30°C. Sclerotia are buff-coloured, varying in size from 1 to 3 mm. in diameter. Their hard rind may be distinguished from the central pith consisting of pseudoparenchymatous structure. They are mostly rounded and though slight variations in shape have been noticed, the change in the colour of the sclerotia has not been observed even after prolonged period of incubation. The fungus culture resembles *Sclerotium rolfsii* in many respects. The perfect stage of the fungus under study has not been encountered and its exact nomenclature is being studied.—M. J. ALBUQUERQUE and H. R. ARAKERI*, Sugarcane Research Station, Padegaon, Bombay.

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SUGARCANE RESEARCH IN INDIA: 1929-1954 — A REVIEW

I—Sugarcane Agronomy and Physiology

THE Indian Central Sugarcane Committee appointed an *Ad-Hoc* Expert Sub-Committee in 1955 to study and scrutinise the present set-up of sugarcane research and development work in progress in the different States and to suggest ways and means of making it more effective. The Expert Committee has during the past few years toured the important sugarcane growing States and, as a preliminary, issued a detailed questionnaire regarding the research work in progress or proposed to be taken up in the near future. The Committee also scrutinised the reports of the Sugarcane Research Stations and records of factory farms and plantation estates. The data, thus collected, together with the suggestions of the Committee, is being compiled on State-wise basis and will be published in due course. The Committee has in the meantime prepared a resume of the research work done on different aspects of the sugarcane crop during the last quarter of a century. This resume covers the different aspects presented in the form of notes on:—

1. Sugarcane Agronomy
2. Sugarcane Physiology
3. Sugarcane Botany
4. Soil Studies
5. Sugarcane Chemistry
6. *Gur* and *Khandsari*
7. Statistics
8. Sugarcane Entomology
9. Sugarcane Mycology

These sectional notes will be presented to the readers of the journal in series. The first of the series, which appears in this issue, covers Sugarcane Agronomy and Sugarcane Physiology.

The present set-up of Sugarcane Research consists of two Central Sugarcane Research Institutes and a chain of State Sugarcane Research Stations and Sub-Stations which are listed here for easy reference in respect of the notes.

1. Central

(1) Sugarcane Breeding Institute, Coimbatore
(2) Indian Institute of Sugarcane Research, Lucknow

2. States

Andhra Pradesh

(1) Sugarcane Research Station, Anakapalle
(2) Sugarcane Research Station, Rudroor

Bihar

(1) Sugarcane Research Station, Pusa
(2) Sugarcane Research Sub-Station, Patna

Assam

(1) Sugarcane Research Station, Jorhat

Bombay

(1) Sugarcane Research Station, Padegaon
(2) Sugarcane Research Sub-Station, Kolhapur

Madras

(1) Central Sugarcane Research Station, Cuddalore
(2) Sugarcane Research Sub-Station, Gudiyattam
(3) Sugarcane Research Sub-Station, Kumaramangalam

Mysore

(1) Sugarcane Research Station, Mandya
(2) Sugarcane Research Sub-Station, Hebbal
(3) Sugarcane Research Sub-Station, Babbur
(4) Sugarcane Research Sub-Station, Bidar
(5) Sugarcane Research Sub-Station, Gangawati

Madhya Pradesh

(1) Sugarcane Research Station, Sehore
(2) Sugarcane Research Station, Dabra

Punjab

(1) Sugarcane Research Station, Jullundur
(2) Sugarcane Research Sub-Station, Gurdaspur
(3) Sugarcane Research Sub-Station, Jagadhri
(4) Sugarcane Research Sub-Station, Bir Posaniwala Farm, Nabha

Orissa

(1) Sugarcane Research Station, Bhubaneswar
(2) Sugarcane Research Sub-Station, Rayagada

Uttar Pradesh

(1) Sugarcane Research Station, Shahjahanpur
(2) Sugarcane Research Sub-Station, Gorakhpur
(3) Sugarcane Research Sub-Station, Muzaffarnagar

West Bengal

(1) Sugarcane Research Station, Burdwan

Risalewala (Lyallpur) and Tarnab (Mardan) lie in west Pakistan.—*Editor.*

SUGARCANE AGRONOMY

A GOOD deal of work has been reported from all over the country on diverse aspects of Sugarcane Agronomy. The salient features emerging from these investigations have been briefly reviewed in the following pages under broad classified heads.

Bulky Manures

(i) *Farm yard manure.*—Application of farm yard manure may be regarded as an almost universal feature of sugarcane cultivation. Besides increasing the yield of crop, it is also believed to improve the physical condition of soils. A large number of trials have been undertaken in various States to compare its efficacy with oil cakes and artificials, either alone or in combination as also to assess the utility of artificials as a supplement to farmyard manure application. The results clearly indicate that on equal nitrogen basis, farmyard manure used alone is by far the least effective treatment in increasing the yield of cane. Thus in Uttar Pradesh (1, 2, 3), farm yard manure applied at 120 lbs. N per acre although outyielding no manure control, proved inferior to oil cakes (*neem* and castor) and sulphate of ammonia at the same nutrient level as also to mixtures of the artificial with cake and farm yard manure on 50:50 N basis. Juice quality under F.Y.M. treatments did not differ appreciably from no manure, sulphate of ammonia showing a distinctly adverse effect. At Risalewala (4, 5, 6) a top dressing of 35 lbs. N as oil cake or sulphate of ammonia over a basal application of 70 lbs. N as F.Y.M. afforded higher yield as compared to F.Y.M. alone at 140 lbs. N per

acre. In a trial at Pusa (7, 8, 9), 40 lbs. N as rape cake with 50 lbs. P_2O_5 as superphosphate gave an yield equal to that under an application of ten tons F.Y.M. per acre which corresponded to an addition of 134 lbs. N+36 lbs. P_2O_5+64 lbs. K_2O.

Although F.Y.M. applied alone is comparatively less effective in raising tonnage of the crop, increased proportions of the same in mixture with artificials do not appear to detract much from the crop yields recovered. Thus at Jullundur (10, 11, 12), it has been found that a sulphate of ammonia-F.Y.M. mixture in 1:2 ratio on Nitrogen basis yields practically the same as one in the ratio 1:1.

The superiority of high rates of F.Y.M. application over lower doses has been brought out at Jorhat in Assam where significantly higher yields of plant as well as ratoon crop were recovered under 120 lbs. N as F.Y.M. over lower rates of application. Similarly, at Risalewala F.Y.M. applied alone or in combination with sulphate of ammonia was found to have a residual effect on the yield of ratoon which was not perceptible in the case of cakes while the artificial applied alone had a distinctly detrimental effect on ratoon yield.

In the Deccan canal tract of the tropical sugar belt, where the soil is under continual irrigation over a period of 25-30 months, it is common practice to apply 20-30 tons of F.Y.M. per acre to improve tilth. Work at Manjri, however, showed such high doses to be unnecessary, 20,000 lbs. per acre being considered sufficient. Later trials at Padegaon indicated beneficial effects of high doses of F.Y.M. in case of Pundia cane only, while for P.O.J. 2878, yields under 10,000 lbs. F.Y.M. per acre were not appreciably inferior to those under 20,000 and 30,000 lbs. per acre. Juice quality was not appreciably affected by the different treatments.

The fact that high doses of Nitrogen applied as F.Y.M. are comparatively ineffective in raising tonnage points to a highly restricted availability during the life cycle of the crop. This would appear to be corroborated by the absence of the depressing effect on juice quality associated with the more readily available artificial fertilisers. F.Y.M. being of a highly variable composition, the question of C/N ratio as affecting availability of the nutrient is important in this connection. There are definite indications of a residual effect on ratoon yields, suggesting a slow release of the nutrient. In the tropical belt, greater stress has been laid on F.Y.M. as a soil improver rather than as supplier of Nitrogen and the best procedure would appear to consist in a judicious combination of this bulky manure with artificial fertilisers.

(ii) *Compost.*—Some attempts have been made to compare the efficacy of composts with F.Y.M. and these do not appear to indicate any appreciable differences in behaviour. At Pusa (89), no significant yield differences were observed as between compost and village F.Y.M., both applied at ten tons per acre. At Meerut and Hardoi in Uttar Pradesh, no differences were likewise observed at dosages ranging from 200 to 400 maunds per acre (3, 13, 14). At Padegaon, cane trash compost proved inferior to groundnut cake (both at 120 lbs. N per acre and in conjunction with basal P_2O_5 manuring at 50 and 100 lbs. with a 150 lbs. N top dressing of sulphate of ammonia and Safflower cake on 50:50 basis) but differences against F.Y.M. were not significant. Juice quality showed a distinct fall under groundnut cake treatments which was not observed for F.Y.M. or compost, pointing to restricted availability of Nitrogen from these sources. Night soil composted by dumping on cane trash in trenches before planting cane has, however, done very well at Shahjahanpur (15, 16, 17) comparing favourably with sulphate of ammonia at 200 lbs. N per acre. The depression in juice quality being much less, sugar per acre was higher than in the latter case. This would appear to open up excellent possibilities with regard to the use of night soil compost.

Green Manures

Researches on various aspects of green manuring have been carried out in different States, particularly with reference to Sannhemp (*Crotolaria juncea*). At Shahjahanpur (3), burying Sannhemp when it was two months old was reported to contribute 60 lbs. N per acre besides improving yield of succeeding sugarcane crops by 43 per cent. In studies on the best age of burying Sannhemp, the amount of Nitrogen turned in was highest at 50 days followed by incorporation after 60 days' growth, green matter yield and yield of succeeding cane being of the same order in both cases. Green manuring supplemented by 60 lbs. N applied as sulphate of ammonia, castor cake or F.Y.M. was associated with higher cane yields as compared to green manuring alone.

At Pusa (Bihar), critical studies on the growth and decomposition of various green manure crops showed that (i) the principal nutrients were at their highest level in 60 days' old crop (ii) the carbohydrate contents (including polysaccharides) gradually increased with age, a maximum level being reached in respect of hemicellulose and cellulose (which greatly helped in nitrogen metabolism in soils) as also for organic nitrogen in a 60-day old crop. The different green manure crops, buried under at this stage, provided 60-90 lbs. of N per acre, Sannhemp proving superior to all others (18). Work on the decomposition of this green manure showed an enhanced rate of decomposition under higher supplies of moisture, when accumulation of nitrates got into stride soon after its burying under. Phosphate manuring of Sannhemp and Soya-bean was found to produce a progressive increase in the Nitrogen content with increasing levels of P_2O_5 application up to

a maximum of 100 lbs. per acre. Manuring with Sulphitation pressmud also proved very effective in raising the yield of a number of green manure crops.

In Deccan (19) green manuring with Sannhemp was more profitable than applying 30 cartloads of F.Y.M. (at Rs. 2/8 a cart), even taking into consideration that a Kharif jowar fodder or early groundnut crop was lost. At Padegaon (20, 21) the system of substituting F.Y.M. by green manure was feasible in combination with 20 lbs. P_2O_5 per acre as artificial. Green manuring with Sannhemp and F.Y.M. at 15,000 lbs. per acre, both in association with top dressings of Nitrogen, showed no significant differences with regard to yield of succeeding cane crop (19, 20). Experiments in Bihar (7, 8, 9) have, on the other hand, indicated the superiority of F.Y.M. over green matter from Sannhemp applied at the same level (both with and without top dressings of artificials) as judged by the yields of the following cane crop. At Shahjahanpur, experiments conducted on the manurial value of different portions of Sannhemp plant have shown highest cane yield when whole plants were ploughed in, incorporation of either aerial or underground parts being distinctly inferior. Utilisation of the stems for extraction of fibre did not, however, detract from their green manuring value. On the other hand, taking a fodder crop between incorporation of green manure and planting of cane was distinctly deleterious and the same held good where the green manure crop was allowed to seed.

Among green manures other than Sannhemp, *Phaseolus bilbous* was found at Kopergaon to afford the same yield and to be ready for burying at about the same time as the former. At Padegaon, a comparative examination of six species of green manures showed that Sannhemp and *Dhaincha* (*Sesbanea aculeata*) supplied maximum amount of green matter, the former being ready for burying three weeks earlier than the latter. The best time of sowing was in June or early July. A local weed *Pateda shevra* (*Desmodium diffusum*) proved to be a satisfactory green manure, affording about the same quantity of green matter as Sannhemp. At Shahjahanpur, Lobia (*Vigna catjang*) and Guar (*Cyamopsis psoralioides*) gave fair returns in the following cane crop but none equalled the performance of Sannhemp.

The chief objection to the practice of green manuring arises from the fact that it stands in the way of raising a *kharif* crop, and rotations as alternatives to green manuring have accordingly been attempted. At Muzaffarnagar (1, 2) cane after cotton had a lower yield to the extent of seven per cent as compared to cane following green manure. This difference could, however, be eliminated by application of top dressings. In the case of ratoon crop, yield under cotton rotation fell by 20 per cent and this could not be offset even by top dressings amounting to a third of the dosage for plant cane. Experiments in Bihar have led to conflicting indications at different places with regard to the effect of maize in rotation with cane, these being variously observed as having no effect on cane yield, or depression on cane yield and lowering of yield which could be offset by manuring. The latter observation was recorded in the case of rotation with *marua* (*Eleusine coracana*) as well. At Padegaon, the effect of a variety of crops such as cotton, groundnut and fodder jowar was compared with fallow and green manuring Sannhemp and *Patada shevra* in combination with a top dressing of 150 lbs. N. Highest yield of cane was obtained with the green manure treatments followed by fallow, cotton, jowar and groundnut. Further work would appear to be indicated in order to settle the question of a suitable rotation (with or without additional fertilisation of cane) as a profitable alternative to green manuring, due consideration being given to the value of the kharif crop recovered.

Molasses and Pressmud

Following Dhar's work on the beneficial effects of applying molasses to soil, field trials were conducted in different States to assess its manurial value. Thus at Shahjahanpur (3, 13), 180 mds. of molasses applied two months before planting was found very effective in increasing cane yields; higher doses of 270 maunds and over proved deterimental to juice quality, particularly in combination with a top dressing of sulphate of ammonia. Where application was made at planting or tillering time, doses higher than 90 maunds of molasses depressed yield. At Gorakhpur and Kanpur (3) molasses treatments were particularly effective in raising ratoon yields. The beneficial effect of molasses was more marked on poor soils as compared to rich soils. There was a distinct residual effect well-reflected on rotational crops. In Punjab (4, 6) on the other hand, no beneficial effects followed molasses application at 180 and 270 maunds per acre. In Bihar (9, 22) both molasses and pressmud of sulphitation process out-yielded a standard manurial dosage of 40 lbs. and 50 lbs. per acre. There were, however, indications of an adverse effect resulting from use of the carbonation products. Later experiments (23, 24, 25) showed pressmud from both sulphitation and carbonation factories to be beneficial, best results being obtained with a dosage of 100 maunds per acre applied before the monsoon. Pressmud also proved effective in the reclamation of *Usar* soils. At Anakapalle (26, 27) molasses application at 26, 52 and 78 lbs. N per acre was associated with high juice quality.

Notwithstanding the beneficial effects of molasses, its application has not been a feasible proposition, except in plantations adjacent to factories, owing to the high costs of transport and distribution. Sulphitation

factory pressmud, on the other hand, is being extensively applied to the land in the main North India Sugar belt of Uttar Pradesh and Bihar.

Oilcakes

A variety of oil cakes is used as nitrogenous manure for sugarcane, the main criterion for selection being their local availability. Comparative trials have been undertaken at Gorakhpur and Kalai in Uttar Pradesh (13, 14), in Bihar (28, 29, 30), in Punjab (10, 12) and at Anakapalle in the South (31, 32, 33). With the exception of *mahua* cake, all other oil cakes have given very good results and there would appear to be little difference with regard to their manurial value. *Neem* cake, however, has the additional advantage of being a termite repellent.

Inorganic Fertilisers

Numerous experiments have been conducted all over the country and the results show good responses of the cane crop to inorganic nitrogen in all areas. The optimum dosage varies from tract to tract, but in the North Indian belt this lies between 100 and 200 lbs. of the nutrient per acre. In the tropical belt, higher doses prove profitable, the recommended rates of application being 150-250 lbs. in Madras, 250-450 lbs. in Mysore, 350-450 lbs. in the Bombay-Deccan and 225-350 lbs. in Hyderabad. These high doses are however preferably applied as a mixture of oil cake and artificials. Response to phosphatic applications is restricted to a few areas only, viz., in Madhya Pradesh where 40 lbs. P_2O_5 are recommended, Bihar (60-75 lbs.) and contiguous areas of Uttar Pradesh, Rajasthan (60 lbs.), Bombay (100 lbs.) and Hyderabad (50 lbs.). In Mysore also, a 20 lbs. dosage of P_2O_5 is considered essential for balanced nutrition. Recently, it has been reported from Uttar Pradesh (34) that P_2O_5 arrests the decline in yield resulting from heavy ammonium sulphate fertilisation in a long range NPK trial. Increasing volume of evidence is also becoming available to show the beneficial role of phosphates in relation to juice quality. Response to potash has been noted in Jorhat in Assam and in recent years on cultivators' plots in the sub-Himalayan tract of North West Champaran in Bihar. Except for those observations, there has been general lack of response and even an adverse effect of potash in some cases. In comparative studies on nitrogenous fertilisers, Ammonium nitrate has proved as effective as Ammonium sulphate and is therefore to be preferred from the economic stand point. Nitrate of Soda has been found superior to Ammonium sulphate in Punjab. So far as phosphatic fertilisers are concerned, superphosphate has always been superior to bone meal. In calcareous soils of North Bihar, Ammophos does better than superphosphate.

Inorganic nitrogenous fertilisers, in general, afford responses of the same order as oil cakes per lb. of N and are therefore more economical. Combinations with oil cakes also do not confer any particular advantage with regard to crop-yield. However, depression in juice quality is associated with artificials and it is therefore advisable to combine them with oil cakes in suitable proportions to tone down this adverse effect. Such a course is also desirable for sustaining productivity of the soil.

Placement of Fertilisers

In view of the restricted availability of phosphates in most Indian soils, placement experiments have been conducted at various research stations. At Padegaon (35, 36) placement of superphosphate at 6 in. depth in deep soils and half way down the ridge in medium soils has proved beneficial, response to Ammonium sulphate also increasing significantly due to depth placement of phosphate. No conclusive benefit, however, accrued from depth placement of superphosphate at Shahjahanpur (17), and Muzaffarpur (37, 38) or Pusa (30, 39, 40). At Shahjahanpur (17), application of superphosphate at sowing of Sannhemp increased yield of green manure as well as of succeeding cane and a similar effect was noted with berseem, senji, meth and pea. Addition of phosphate at the time of burying Sannhemp depressed the yield of following cane.

Time of Application of Manures and Fertilisers

Experiments conducted at a number of centres would appear to indicate that application of fertilisers at any time between planting and earthing up generally produces similar results. In an experiment at Mnzaffarpur (1, 2), application of fertiliser in furrows at planting was reported to have adversely effected germination and yield. This effect was, however, absent under conditions of adequate soil moisture. Water requirement studies by Khanna and Raheja (41) indicated a better water economy with application of complete manurial dose (organic or inorganic) at planting as compared to split application at planting and earthing. In Bihar (28, 29, 30), oil cakes have been found to be most effective when applied at or before planting. In the Deccan, a recommendation based on work at Manjri regarding application of oil

cake—Ammonium sulphate mixtures in three instalments during the pre-monsoon period in three different combinations was tested out at Padegaon. Neither the composition of the three instalments of manuring nor their times of application was of any material consequence (21).

Water-cum-manure

Experiments conducted at Shahjahanpur, Muzaffarnagar and Gorakhpur in Uttar Pradesh (13, 14) using nitrogen doses ranging from 60 to 180 lbs. per acre in conjunction with 2, 4 and 6 hot weather irrigations, revealed significant interactions in certain years, definite indications being available to show that heavier doses of Nitrogen must be accompanied by an adequate number of irrigations for optimum results. At Jullundur, (17, 18, 19), it was found that while both Nitrogen and water could individually increase the yield, there was, in general, no interaction between the two factors. In Bihar, water requirement studies by Khanna and Raheja (41) have indicated that application of complete dose of fertilisers at planting time promotes water economy. These workers also report that Niciphos II is less economical from the standpoint of water expenditure than castor cake. Application of potash was also found to reduce the water expenditure per unit of dry matter produced. In trials conducted at Mushari in this State (8, 9, 22), no special advantages of irrigation have been found to be associated with any particular type of manuring. In an experiment at Padegaon (35, 36) conducted with the variety Co. 419 under different combinations of irrigation with nitrogenous and phosphatic fertilisers, high irrigational levels in conjunction with low doses of Nitrogen caused reduction in yield, as against a beneficial effect of larger quantities of water applied with high doses of nitrogen. So far as interaction with Phosphate was concerned, a deleterious effect of high irrigation was manifested in the absence of phosphates, the depression in yield accompanying a rise in the irrigational level from 115 to 130 acres inches amounting to as much as five tons per acre. As regards juice quality, lower levels of both Nitrogen and irrigation favoured superior sucrose values.

Spacing-cum-manure

In experiments in Uttar Padesh (1, 2, 14), it was found profitable to reduce the spacing to 2½ ft. under low nitrogen levels, wider spacing being necessary for optimum yields where nitrogen fertilisation was high. Juice quality was not significantly affected by the spacing factor. On the other hand at Anakapalle (42, 43), spacing afforded a good response irrespective of manurial dosage. In N.W.F.P. (W. Pakistan) (44) again, closer spacing resulted in higher yields although juice quality was adversely affected. At Padegaon, 3½ ft. spacing in conjunction with a 600 lbs. dose of N did significantly better than one of 3 ft. under the same fertiliser application. In North Bihar, 3 ft. spacing was found to be most economical with medium thick varieties and 2½ ft. with thin varieties (45).

Ratooning

Ratoons usually give lower yield with better juice quality as compared to plant cane. In second and third ratoons, the outturn falls to an uneconomic level. Long-term experiments at Mushari in Bihar and Kalai in Uttar Pradesh have shown that ratoons are not more liable to insect attack than plant cane and no correlation exists between infestation of parent crop and that of succeeding ratoon. The practice, therefore, is in no way objectionable from the entomological point of view. On the other hand, with proper care, ratoon yield can be as high as that of a plant crop although the cost of cultivation is much lower in the former case. Encouragement of ratooning would therefore conduce in a great measure to reduction of the cost of production of sugarcane. The practice must, however, be extended no further than the first ratoon stage for the present and it would be essential to ensure manuring at somewhat higher rates than for plant cane and to bestow particular care on the various aspects of culture.

Ratoons show ready response to manuring. At Muzaffarnagar (37, 38), 140 lbs. N per acre appeared to be the optimum dosage. Experiments in Punjab (46) show significant improvements in yield of first, second and third ratoons from doses of 70, 140 and 210 lbs. N respectively. Increases due to reduction in irrigation interval from 15 to 10 days were also significant. On the other hand, weeding and interculture had no effect. At Patna, (47) first ratoons of most varieties have given yields higher than those of plant crop.

The time of harvesting plant cane for ratooning is an important factor, later harvests having proved superior at Muzaffarnagar with regard to the yield of ratoon. At Pusa, Bihar, harvesting the parent crop flush with the ground has proved superior to harvesting flush with the ridge (22, 23).

Rotational

Of six rotations examined in Uttar Pradesh (17, 47) the rotations Sannhemp-green manure-fallow-sugarcane and Arhar-paddy (or Kodo)-fallow-sugarcane proved the best. At Jullundur experiments with

sugarcane variety Co. 396, which could be harvested early enough to be followed immediately by a crop of wheat, have made possible a shorter and more remunerative rotation involving maize, senji, cane and wheat on a two-year cycle. Work at Padegaon has indicated superiority of cotton over groundnut or jowar as rotational crops with sugarcane. In Bihar, maize as a preceding crop has proved distinctly detrimental to cane yield as compared to summer fallow or a pulse crop (48). Similarly, *arhar*—ground-nut-sugarcane rotation has given highly profitable results both in Uttar Pradesh and Bihar (49).

Irrigation

In a series of experiments in Uttar Pradesh (50), hot weather irrigations have markedly increased the yield, the recommendation involved consisting of 3 to 4 pre-monsoon and 1 to 2 post-monsoon irrigations. Frequent light irrigations have proved superior to a few heavy floodings. At Jullundur, liberal irrigations have been found essential for all varieties. Frequency of irrigation must be high under Punjab conditions, increase in the interval of hot weather irrigations from 10 to 15 days proving markedly detrimental to tonnage. In Punjab (51) no differences were accountable to the frequency-quantity relationship or to a differential frequency at a constant level of water. Responses were high up to a level of 50 acre-inches, above which there was a decline. In North Bihar (23, 24, 25), the utility of irrigation depended on the character of the season, rise in tonnage due to irrigation being proportional to dryness during the hot weather period in the crop's life cycle. In South Bihar (52, 53, 54) on the other hand, three hot weather irrigations in addition to one immediately following planting constituted the most effective treatment from yield considerations. Additional irrigations up to a maximum of 11 were beneficial but did not prove economical. Recent work dispersed over North Bihar has revealed highly significant gains in acre-yield and quality resulting from 3 to 5 hot weather irrigations, each of 80,000 gallons per acre. Post-monsoon irrigation has helped reduce field driage besides giving higher sucrose per cent cane (55) and this recommendation is now being adopted in increasing measure. At Gudiyattam, Madras (56, 57, 58) in the South, irrigation intervals of 6, 12 and 18 days made no difference in yield. Early maturity was, however, associated with frequent irrigations. Effects on ratoon yield conformed to those on yield of plant crop.

Time of Planting

In the western areas of Uttar Pradesh, planting between mid-February and mid-March has been found to give best results while in the eastern tracts of this State, the best time of planting appears to be between the middle of January and middle of February. In the latter area, October planting has also given high yields. In Bihar, October planting shows best performance, yields decreasing progressively with advance in the time of planting from October to March. At Risalewala, cane planting is best done during the first three weeks of March. In an experiment at Gudiyattam (59) in Madras, a May-planted crop of Co. 419 harvested after 19 months in December gave a considerably lower yield than the combined outturn of a March-planted crop and its ratoon, covering a total period of 21 months. In the same experiment, May-planted Co. 449 gave 44·9 tons (as against 44·7 tons for Co. 419) along with high juice quality but the crop had to be propped up after the twelfth month. At Padegaon, Bombay (21, 60, 61), July, October, and January plantings afforded yields in the same descending order, corresponding more or less with the length of the growing season. Increase in yield in July over January planting was statistically significant, C.C.S. per acre was practically the same under July and October plantings but July-planted Co. 419 ripened earlier. In experiments in Mysore, a significant interaction was observed between variety and time of planting. Yields were generally higher in crop planted between July and October as compared to later plantings. Maturity was influenced both by the age of crop and time of planting. An interaction between planting date and seed rate was reported from Risalewala, April planting necessitating a higher seed rate to the extent of 60 per cent over March-planting.

Time of Harvest

Harvesting in the different months from December to April showed no marked yield differences in three varieties at Shahjahanpur (17, 50). At Pusa (30, 39, 40), yields decreased as time of harvest advanced from December to April, peak juice quality being recorded in February.

Seed Cane

It is well known that planting of setts from top portions of the cane stalk affords better germination. Soaking of setts is also recommended by the different research stations. In some areas, growers keep seed cane buried in pits. Experiments in Bihar have, however, shown that at least in the case of early varieties, it is a better practice to leave the cane standing in the field instead of burying it. Vegetatively-grown material

gave significantly better germination, early stand and final outturn. A dominant influence of weather on quality of seed material and bud viability was also observed, quick and full germination being also found to be a desideratum under rainfed conditions. Planting of top setts invariably gave better results than both bottom and middle setts (23, 24, 25). At Anakapalle (26, 43), it was found that putting the entire cane into pits and covering it with earth for 15 days was as good a method of preserving seed cane as heaping it covered with trash in shade or planting it vertically in a puddled field and covering it with paddy straw kept wet for 15 days. Another experiment showed that setts with two to three week-old germinated plants gave better results than the usual method of planting setts.

Seed Rate

At Manjri (63, 64), it was found that seed-rate could be reduced to 10,000 three-budded setts per acre without occasioning loss in yield. Later work at Padegaon showed that it could still further be reduced to 8,000 two-budded setts. At Pusa, (28, 29, 30) 20,000 three-budded setts per acre has proved to be the most economic, while at Risalewala, Punjab, 40,000 two-budded setts afforded optimum results. Similar trends have been observed at Jullundur (10, 11, 12) as well.

Spacing and Method of Planting

In spacing experiments at Anakapalle (42), highest yield of cane was obtained under 4×4 link spacing. No interaction was noted between spacing and irrigation. At Patna (52, 53, 54), the difference in outturn between 3 ft. and 4 ft. spacings were non-significant. Results in Bengal (55, 66) were in favour of 3 ft. spacing and the same has been established at Pusa (9, 22, 23) as well. At Jullundur, increase in spacing beyond 2 ft. did not produce any improvement in yield or juice quality. At Shahjahanpur, choice of spacing, as also method of planting, was dependent on fertility and cultural levels and for intensive cultivation where high yields were expected, wider spacings were recommended along with trench planting. At Patna and Pusa (22, 52), flat planting proved superior to trench planting. Marked interactions of trench treatments with varieties and manuring were also observed.

Preparatory Cultivation

Experiments on preparatory tillage conducted at Lyallpur revealed no treatment differences between various combinations of ploughings with furrow-turning, local plough and horse-hoe. At Delhi, the depth of preparatory ploughing showed no association with yield. At Karnal, trash mulching invariably out-yielded the ordinary soil mulch treatment. In Bihar, trash mulching gave an increase in yield to the extent of 11 per cent besides conserving soil moisture and nitrate and reducing incidence of stem and root-borers (23, 24, 25). Similarly, seed-bed preparation treatments produced no significant differences in yield of plant or ratoon crops at Jullundur (10, 11).

Earthing-up

At Padegaon (19, 20) non-earthed up plots showed a tendency towards higher yields and earthing-up was considered as offering no special advantages. High earthing-up as practised in the Deccan Canal Area, though acting as a support for lodging varieties, was considered a disadvantage as it meant more water for irrigation. Those conclusions are contrary to thep opular belief in India, as well as abroad, that earthing-up is a wholesome practice.

In Bihar, early (mid-May) earthing not only increased proliferation, consequently raising the tonnage but also helped in mitigating the stem-borer trouble (23, 24).

The broad ridge method adopted for most crops in Gujarat (now in Bombay State) was tried at Padegaon for cane (21, 60). The yield differences were non-significant in the first year, and the saving in irrigation was not much in the second year. At Shahjahanpur, earthing and binding (also called wrapping) were found to be prerequisites for an intensively cultivated crop.

Wrapping and Propping

Anakapalle experiments (26, 27) indicated that cane wrapped and propped with wire gave a significantly higher yield. Cost of production per ton of cane was more in the case of stooked (clamped) treatment than in the one with bamboo or wire propping. Due to less lodging, wire-supported cane gave a better quality juice. This latter treatment proved best at Gudiyattam, Madras, also. Recently a new method of propping canes has been evolved at Gudiyattam (59), termed the " trash twist " method where no

extraneous materials are used, thus completely cutting out the cost of bamboo and wire. It involves use of ropes made by twisting together the dried and the green leaves of the canes, pulled out at a height of $2\frac{1}{2}$ to 5 ft. above ground level, the operation starting when formation of stalk has progressed to that height.

Interculture

It has been reported from Jullundur (46) that hoeing with " Kasola " by manual labour gave better results than interculture with bullock-driven implements, with and without labour. The increased yield was enough to cover the additional expenditure of manual labour. Both interculture and hand-weeding had beneficial effects at Pusa (67). In experiments at Shahjahanpur the differences were non-significant.

Stubble Harvest

At Pusa (22, 23, 24) digging out the stubble and cleaning it for mill-supply with the rest of the cane was found to increase the total outturn per acre by nine per cent with no significant loss in juice quality. The extra outturn more than covered the cost of digging out the stubbles and cleaning them. The procedure conferred several other advantages such as elimination of borer population, enhanced rate of nitrification in soil and ease of working the soil for subsequent cropping.

Intercropping

Intercropping with maize affected tillering and depressed the yield of cane at Padegaon, Bombay (85, 86). This was not fully made up by the application of 50 lbs. N per acre to the cane crop after harvest of maize, except where maize was dibbled sparsely at 3 ft. intervals between cane rows. In Uttar Pradesh, intercropping with gram gave promising results; with mustard, net returns per acre were still higher notwithstanding a depression in the yield of cane (49).

Future Lines of Work

It would appear from the foregoing pages that considerable work has been done on various aspects of sugarcane agronomy. In what follows, certain lines of work have been indicated which should be further developed so as to work out means for maximisation of tonnage and maintenance thereof under intensive cropping.

Green manuring is another field where useful work can be done, the object being to find out green manure crops for different tracts which could afford some grain to the cultivator besides serving as an agent for soil enrichment. One such crop is *Moong* type 1 which has admirably served this purpose (49). Similarly, suitability of different species of weeds as green manure should be examined. In Bombay, the weed *Patada shevra* has shown very promising results. Further, the composting value of different weeds needs to be examined so as to select NP-rich materials suitable for the purpose.

Crop rotations have to be further experimented upon in different tracts to work out the most profitable cycles appropriate thereto. The possibilities of liquid ammonia as a cheap source of Nitrogen remain to be explored. Newer concentrated fertilisers like urea also need to be tried extensively in the country. The question of phosphatic fertilisation of cane must also be re-examined in all areas on a long range basis as sufficient indications are now forthcoming to indicate its importance in the maintenance of high tonnage and juice quality.

In areas of restricted phosphate availability, placement methods need to be further experimented upon as also the suitability of placing pellets or briquettes applied in the root zone.

Similarly, potash responses have to be examined extensively on cultivators' fields, definite indications of deficiency pockets having recently been obtained. A systematic beginning has likewise to be made aiming at assessment of trace element requirements under cultivators' conditions.

It is of utmost importance to conduct extensive manurial experiments on cultivators' fields under varied types of soil and climate so as to determine the optimum schedules appropriate to each type. A judicious combination of organic manures and inorganic fertilisers has been stressed earlier and it would be necessary to arrive at this combination in relation to the soil unit by actual experimentation.

Use of over-head sprinkler irrigation, now becoming popular in other countries owing to introduction of light pipes of aluminium or other materials, should be examined under conditions obtaining in the country in order to examine if this method could replace or be combined with conventional irrigation procedure to effect economy in water and yield more favourable results.

A suitable system of weed control has to be evolved so as to eliminate competition with the crop for nutrients and moisture. In this connection, an examination of various hormone-type weedicides in relation

to the varying weed flora found in different tracts would be particularly important. In this connection, residual effects on soil fertility must also be studied.

Lastly, the possibilities of mechanisation need also to be investigated, involving the use of rotavators, combined harvesters and loaders and such other equipment in large plantations.

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SUGARCANE PHYSIOLOGY

THE work done in Sugarcane Physiology has been reviewed below under eight classified heads, viz. (i) germination, (ii) tillering, (iii) growth, (iv) nutrition, (v) water relations, (vi) metabolism, (vii) flowering and (viii) maturation and juice quality.

Germination

Considerable work has been done with a view to determining the various factors conducive to good germination. Important among these may be mentioned the use of setts with three or more buds and having larger amounts of internodal tissue (1, 2, 3, 4); pre-harvest manurial treatment of seed cane (5); various requirements with regard to chemical composition of setts such as high glucose ratio (6), presence of starch (7), appreciable amounts of amide nitrogen along with high glucose (3, 8) and a critical level of sett moisture (9) besides low fibre and wax contents of planting material along with softness of rind (10, 11). Top joints and immature parts (12), and this comes as against thicker ones (13, 14), have been associated with superior germination. Time lag between cutting of seed cane and its planting also has a marked influence in this regard (9). Among external factors, temperature is of special significance, warmer temperatures being favourable (2, 15, 16). A range of 50° to 78°F. appears to be ideal (9). Adverse effects of low temperature and other factors have been found to be neutralised by nitrogen applications (3, 13).

Beneficial effects of manganese, boron, copper and zinc have been recorded in certain areas (17). Depth of planting for optimum germination has been found to depend on soil type (11, 13). The ideal moisture for good germination likewise differs in different tracts (9, 10, 11, 14, 18-22). Pre-planting treatments of setts such as soaking in cold water (2, 10, 11, 23-28) or hot water (29), standing canes vertically with ends immersed in water (6, 30), soaking in saturated lime solution (10, 12) and in solutions of other substances such as ash, lime-magnesia (6), acids and alkalies of various pH ranges (51), growth promoting substances (52, 53), termite preventives (34) and trace elements (35) have been reported to improve germination. Preserving setts under cow-dung (36), and topping of canes a week before planting (36, 37) have also proved useful.

Tillering

Greatest number of successful tillers emerge before the month of May (38) and these are the most heavy (39), flower profusely (22), contain richest juice (40), have a greater chance of survival and contribute most to the yield, besides determining the quality ratio (22). All attempts have therefore to be directed towards improving early tillering. Nitrogen plays a dominant role *vis-a-vis* tiller production (20, 23, 28), ammonium sulphate, in general, producing the highest response (56). Phosphorus (41) and trace elements like copper and zinc (17) also have a favourable effect. Although largely a varietal character, tillering can be improved by other factors as well (24), such as early planting (15), pre-monsoon irrigation (28), appropriate moisture status of soil (18) and right spacing between rows (59). Mean temperatures of the order of 80°F. prove most favourable for tillering (16). Delayed germination prolongs the tillering phase (42) and brings about greater mortality (27). Tiller mortality varies with varieties (20, 23, 28), nutrition (22) and amount of irrigation water (28).

Growth

The bulk of the growth of sugarcane is during the monsoon period (2, 11, 43) and this is the critical phase affecting final tonnage of the crop. Growth has been found to increase progressively with rising temperatures up to 88°F. (44). Differences in humidity and temperature in different months are reflected in differences in internodal-length (39). High correlations have been observed between growth on the one hand and humidity and number of rainy days on the other (8). Level of sub-soil water table and manuring are liable to mask the influence of climate (45). Micro-climatic studies have indicated atmospheric humidity to be the chief factor affecting growth (12, 46). Depression in growth has been reported to result from breaks in the monsoon (47) and from conditions of water-logging (48). Magnitude and distribution of rainfall from planting till the advent of winter have a profound influence on growth (49). A soil moisture range of 10-15 per cent has been found ideal during the grand growth phase (50). Soaking of setts in a solution of pH 6·8 is associated with increased dry matter output of the crop (51). Leaf catalase activity is found to be positively correlated with growth (52). Daily treatment with rice washings has been reported to increase vigour of plants (53) and sett material from this treatment also produces vigorous plants (54). Pre-monsoon shoots show a better expression of growth as compared to post-monsoon ones (55). Delay in planting adversely affects various growth criteria (18, 21, 28, 56) while wide spacing with high nitrogen has been found to improve them (21). Nitrogen fertilisation (18, 21), as also frequent irrigation (57), proves beneficial in this regard.

Root development has been found to be a continuous process enabling the plant to adjust to changing conditions of soil (58). In *Usar* soils, roots are branchy at deeper layers, the laterals being rather thick (50). Root systems are poorer in clayey soils as compared to light types (50, 57, 59) and are also well-developed in shallow soils (15). Normal root growth occurs in a pH range of 6·1 to 7·7 (10, 30). Cane roots have been found to be positively aerotropic (58). Nitrogen manuring tends to make root systems superficial and slender while phosphates improve thickness of main roots and laterals (10). Saline water has been found to exert a harmful effect and water level controls distribution of roots (58). A soil moisture above 15 per cent promotes superficial feeder roots while below the five per cent level, a deep root system is induced (50, 57). Under wilting conditions, the root system is found to be dead, a mass of thick new living roots being, however, formed four days after watering (60). Canes on the windward side have been associated with stunted growth and higher root development along with low shoot and root weights (61). Penetration limit of roots is reported to vary with soil texture (10, 30). Higher soil temperature favours penetration, lower soil temperatures causing flaccidity of roots at the ends. Varieties having Spontaneum blood show highest root tensile strength, noble canes recording lowest values. Root systems have been differentiated as semi-mesophytic, semi-xerophytic and xerophytic (10) and also classified as surface feeding, buttresses and ropy roots (14). Shoot roots are much thicker than sett roots, have larger and stronger root caps, are less fibrous and grow faster. The number of sett roots developed is a varietal characteristic, larger numbers developing within the first ten days in tropical canes as compared to Indian and wild canes (58). Certain root primordia remaining dormant are considered a valuable provision against adverse conditions (56). Longevity of sett roots has been found to be greatest in *S. spontaneum* and some of its hybrids (58). Sett roots show a clear decline in dry weight between four to eight weeks after germination with copious production of shoot roots. Formation of stem in late-sown plants lags behind at the end of summer, but is made up later on. Percentage of stem increases with water duty (10). No consistent trends are observed with regard to the stem/leaf ratio for good growth (2, 8, 24, 60) but the shoot/root ratio manifests characteristic behaviour (13).

Nutrition

The relative importance of the nutrients from the stand-point of uptake by sugarcane has been found to be as K N Ca. P (8). Consistent with the two flushes of growth of an *Adsali* crop, it has two peaks of absorption. Uptake of N and Ca. continues up to flowering, maximum uptake of P and K occurring earlier, followed by a decline (35). During drying, leaves tend to return varying proportions of NPK to the plant (8). Sugarcane has been found to absorb nitrate nitrogen rapidly (45). Deficiency of Nitrogen in soil is reported to depress uptake of P and K (35, 45), particularly of the latter (62). In Bombay, application of P in soil had no effect on its uptake while K application increased K with decrease in N and P (41). In the same area, a narrow N/P ratio resulting from uptake of P under soil application of the nutrient has, however, been reported later (63). Omission of both P and K increased N in NPK unit of plant, omission of K increased P and reduced N while omission of P increased K and reduced N and P (64). Capacity of nutrient absorption has been found to be a varietal feature (65), being highest at the pre-flowering stage. Flowering stools absorb more nutrients and after flowering, there is a decrease in N with rise in P and K (64). Leaves have the highest N content, followed by sheath and stem (66). Crystalloid nitrogen is the dominant component of stem in later stages (64). Chlorophyll content increases with N application (67). The amount of N taken up by sugarcane varies from 26·7 lbs. per acre in Bihar to 86·8 lbs. per acre in Bombay. In U.P., average uptake by a 30-ton crop works out to 81·7 lbs., the mean value for the country being 87·3 lbs. (68). Deficiency of N lowers tillering, length of all root classes, area of leaf, internodal length and thickness (18·69). It increases P and K content of juice, lowers glucose and raises brix, sucrose and purity values (55). Respiration is unaffected (70) but chlorophyll content is lowered (67) although this is not marked at maturity (55).

Phosphorus is next in importance only to nitrogen and it stimulates early and vigorous tillering (18). In Bihar, phosphate manuring leads to higher P status of leaves, the maximum being recorded in August. Inorganic P is highest in May (25, 71). Dry leaves contain less P than green ones due to its translocation (63). Absorption of P decreases with age but increases with higher N applications (72). Irrigation is reported to enhance availability of phosphates. At Padegaon, phosphate application is found to increase length and girth of internodes, leaves becoming broader but thinner. It increases arrowing but maturity is unaffected (63). P along or in combination with K improves respiration but has a depressing effect when in combination with N (73). It decreases chlorophyll when applied singly or with K (41, 64). A 30-ton crop in U.P., is estimated to remove 102·1 lbs. P_2O_5 per acre from the soil, the average figure for the country being 46·6 lbs. per acre (68). Phosphorus deficiency induces poor root extension (55), lower leaf area and leaf number (18) reduced height and thickness of cane and shorter internodes (69), lower brix (55), juice extraction and sucrose content with increased starch and total carbohydrate contents (62), super-normal respiration (70), increased chlorophyll content and better utilisation of nitrogen in pigment formation (67). Phosphorus deficiency at maturity results in high pigment content.

Potassium has been reported to be beneficial from the standpoint of tillering, mature stalk numbers, yield, sucrose content and purity of juice and production of sugar per acre (16). Its migration from dying leaves to stalks has been recorded (63). K improve assimilation efficiency and respiratory activity during the first half of the life cycle but depresses assimilation in the second half (72). In combination with N and P, it improves tillering (41). Its application appears to retard deterioration in juice quality and improve juice purity besides reducing pith formation (64) and enhancing respiration and yield (72). Average uptake of potash per acre has been found to be 85·9 lbs. in U.P., as against a mean value of 40·5 lbs. for the country (62). Potash deficiency reduces root extension (55), length of leaf (62), thickness of internode (62, 75) and length of cane (55). It also leads to reduction in brix, sucrose and total carbohydrates (55, 62), induces super-normal respiration (55, 70) and raises the concentration of chlorophyll a, carotene and xanthophyll at maturity (67). The average uptake of CaO by a 30-ton crop is 86·4 lbs. in U.P. against an All-India figure of 39·4 lbs. (68). Magnesium deficiency has been associated with thin internodes and depressed yield (18). In the Bombay-Deccan, spraying of boron has afforded considerable advantage with regard to sucrose formation and sugar recovery (17). In small doses, boron increases vegetative growth (74), 10 ppm improving tillering and 5 to 15 ppm toning up juice quality. It also helps in overcoming deficiency of P and K (69). Boron deficiency has been found to decrease internodal length (18). Lower manganese contents have been associated with chlorosis of leaves (26).

Water relations

High-yielding varieties are reported to have low water-requirements (76), relative efficiency of water requirement varying with variety (30, 77). Low water-requirement has also been associated with varieties having extensively developed root systems, high cell-sap concentration in stalks and a high level of hydrophyllous colloids in leaves (77). Drought resistance does not appear to be related to water-requirement (78). Two critical periods of high water-requirement have been recognised in Bombay (mid-May to mid-June and mid-October to mid-November), the former being more important (64). Daily water-requirement is high at both formative and grand growth stages, being highest at flowering and lowest at maturity (79). Absorption of water is found to be most marked at the nodal zone (80). Transpiration is reported to be highest between noon and 2 p.m., being negligible at night (79, 81). Rolling of leaf lamina and lower number of stomata on upper surface are stated to lower transpiration (11), transpiration rate being also found to depend on the total leaf surface as also on the meteorological complex (81). Transpiration increases with temperature and decreases with humidity (79), variations arising from soil moisture being also reflected in characteristic curves (55). At a given moisture content, transpiration rate is determined by total leaf area (79). A 40 per cent reduction has been recorded at maturity (78).

Duration of time before wilting is found to depend on the variety, age, soil type and season (45, 79). Thin and spreading root-systems have been associated with greater efficiency in shallow soils. Respiration and carbon assimilation are considerably lowered at wilting (81). Water-content of plant parts is found to vary in different months (23), hydration of tissues being conditioned by environments as well as age (57). Changes in irrigation dose do not affect water content materially in all varieties (23) but these are found to vary with time of day and planting time (57). Varieties with broad leaves have, in general, proved drought-susceptible (18). Anatomical adaptations in roots of sugarcane help in resisting drought (82). In general, drought resistance is associated with transpiring surface, quantity of roots and depth of penetration (64). A fast germinator appears to make better use of moisture (83), varieties with large numbers of superfluous tillers wasting water. Drought resistance appears to go with a larger percentage of semi-xerophytic roots (10, 79), a good vertical and horizontal spread of roots (84), capacity to tap larger area, thickness and number of tertiary and ternary roots (85), high root pressure (10), low ratio of day/night transpiration and smaller transpiration per day (55). It also depends on the amount of transpiring surface (64), number and size of leaves as also leaf area (84). Varieties with poor leaf surface and small size of leaves have been classified as resistant (55). Mechanism of rolling of leaves has been associated with resistance which again is related to the number of bulliform cells per unit area (84). Thickness of cuticle (55) and lower cell indices are associated with resistance as determined by chromosome number. Stomatal density and size decrease with resistance, sunken stomata being another characteristic of resistant forms (84).

Higher osmotic pressure and concentration of solutes induce resistance to drought (55) which is also associated with low and high respiration rates in roots and leaves respectively. Drought conditions have been observed to depress juice quality besides causing considerable accumulation of intermediate products of carbohydrate and nitrogen metabolism (86). Submergence occasions disorders in morphology and plant metabolism (50), inducing aerial rooting, bunchiness, softer rind, rotten phloem tissue (10), profuse nodal rooting (85) and aerotropism in certain varieties (11). Development of aerenchyma on submerged nodes has been reported (87). High oxidase, low invertase, low organic nitrogen and proteins, high G/N ratio and low moisture content are some of the other features resulting from submergence. Tolerant and susceptible

varieties exhibit characteristic respiration curves under conditions of submergence (30). Canes under swampy conditions ripen earlier (76, 49, 83, 85, 88) but are poorer in content of juice (50) and richer in invert sugars, gums, total colloids and non-protein nitrogen (89). Moderate water-logging causes maintenance of juice quality for long periods owing to development of chlorophyceous and cyanophyceous algae (87). Capacity of aerotropism in roots of certain varieties is related to resistance to conditions of water-logging (10, 11). Narrow foliage (10, 11, 30), a coating of wax (10), solid texture and hard rind (10), low permeability and high pectin content (30) have been found to characterise tolerant varieties. Under conditions of deficient soil moisture, lower development of feeder roots has been noted (50). Increase in irrigation interval is found to decrease arrowing (14, 33, 90) while frequent irrigation during the early stages induces early maturity (57).

Metabolism

Sugarcane leaves have been reported to fix atmospheric nitrogen (25, 54, 75, 91, 92). High accumulation of organic nitrogen compounds in the early stages is found to be associated with high efficiency of mineral uptake, net assimilation rate and high photosynthetic activity (42). Nitrogen metabolism is adversely affected by long breaks in the monsoon during the grand growth stage (25, 26). Protein synthesis is high during germination, reaching its maximum during tillering which is followed by a gradual decline till the senescent phase (93). Percentage of glucose, sucrose and starch in attached leaves of sugarcane is found to increase with increase in the period of illumination till 2 p.m. with a subsequent decline irrespective of the exposure. Such a decline is considered to be due to the translocation of these substances to the leaf sheath and stem and their utilisation in down grade metabolism or otherwise (94). Rate of photosynthesis, as determined on the basis of CO_2 absorbed, is reported to vary with light intensity, temperature and CO_2 concentrations. With intern al conditions coming into the picture besides intensities of the external factors, curves obtained are not of the ideal Blackman type. Under conditions of controlled illumination, temperature and CO_2 concentrations, significant increases in assimilation rate have been recorded with progressively higher doses of N in conjunction with P and K. Similar effects have been attributed to P when applied in combination with NK and to K applied with NP (95).

Long breaks in the monsoon during the grand growth phase are reported to depress carbohydrate metabolism (25, 26). Assimilation rate increases with increasing light intensity in the range 90-1, 875 feet candles. Between 20°C. and 30°C., increased assimilation is observed with rise in temperature while between 50°C. and 40°C., a rise up to 34°C. is followed by a decline (95). Rate of assimilation increases considerably with increase in CO_2 of the atmosphere and under natural conditions CO_2 is reported to limit assimilation and growth (96). Synthesis and accumulation of sucrose in the developing internodes of high sugar varieties proceeds at a much higher rate compared to others, providing a useful basis for the early selection of high sucrose seedlings (97). Varieties with higher chlorophyll concentrations show a narrow range of daily fluctuation in respiratory activity. Characteristic diurnal fluctuations in respiration rate have been recognized, the optimum temperature lying below 100°F. with a decrease in respiration above the 104° F. mark (98). Respiration is reported to be retarded when photosynthesis becomes slow (99). Variations in respiration rate appear to be related more to glucose fluctuations than to those in sucrose, particularly in tillers of the older group (100). High carbohydrate content of tissue is generally associated with low respiratory activity (12). Nitrogen has been observed to depress respiration particularly when in combination with other nutrients. P alone or in combination with K improves respiration but has the opposite effect when applied with N (101). P deficiency on the other hand, has been reported to induce super-normal respiration (70). K enhances respiration rate unless in combination with N and P (101). Deficiency of K also leads to super-normality in respiration (70). A combination of minor elements has been found to increase respiration but the effect is much less apparent when these are applied along with NPK (101). Irrespective of the portion from which a sett is selected, intensity of CO_2 output declines with increasing age of tillers. High rate of respiration in apical internodes and low rates in the basal portion have also been noted (102). Submerged organs (stems and roots) generally exhibit higher respiration after 5 to 8 days; in both plant and ratoon crops, partial submergence results in an initial rise in respiration rate which is followed by a decline in the case of plant crop (101).

Flowering

Initiation of floral primordia is noted by end-August in both early and late-flowering varieties, earliness or lateness depending primarily on differential growth rates of the inflorescence (33). Sudden fall in temperature and rise in humidity have been considered responsible for the change from vegetative to reproductive phase (103). Heavy rainfall combined with high temperature and humidity induces flowering in North India (104). Flowering induced by a change in climate decreases considerably with acclimatisation (85). Delay in planting causes a tendency to diminished arrowing. Increased N lowers the number of arrows

formed (15, 18) and also delays and inhibits flowering even in profusely-flowering varieties (105). Treatment with rice washings or with buffered Knop's solution containing the different trace elements induces flowering in varieties which had nearly lost flowering ability (53). Zinc sulphate application has been found to produce flowering in scarcely-flowering varieties (106). Among the factors influencing flowering, photo-period has been considered very important, every variety having a day-length range for flowering (103). Non-flowering forms, when subjected to short day of two hours before commencement of flowering season, have shown flowering (107) while flowering forms of certain *spontaneums* are found to flower very late with the same treatment (108). Hastened or delayed flowering has been effected under different day-length treatments (106). Photo-periodic studies at Coimbatore have thrown considerable light on various other aspects of the problem (33, 90, 54). High Nitrogen coupled with frequent irrigation tends to delay and reduce flowering in early varieties (50). By simply adjusting the conditions of manuring and irrigation, it has been found possible to induce flowering or control the time of flowering (109). In general, arrowing is found to be profuse under optimum moisture conditions (3, 15, 19, 20).

Water-logged conditions delay flowering in flowering varieties and have no effect on non-flowering ones (90). Characteristic leaf moisture differences have been noted as between early, late and non-flowering varieties (33). Flowering responses to coloured light differ considerably with varieties (54). Lopping off of green leaves causes marked changes in flowering behaviour (33). Arrowed canes show profuse stooling from leaf axils (110) which is particularly notable under low nitrogen manuring (41). In general, flowering indicates cessation of growth (49). The canes, however, do grow at a very slow rate (82). Number and weight of green leaves are greater in unarrowed canes (14). Arrowed canes tend to lose weight after arrowing due to development of pith, and millable length gets shorter as a result of formation of auxiliary buds at the top (111). Greater pith formation (82, 111-113) and low moisture contents of leaves and stalks are characteristic of flowered stools (81). Arrowed cane show higher brix and sucrose for two and a half months after arrowing till the commencement of deterioration phase (104, 82, 113, 114, 115) when the rate of fall in sucrose is more rapid than in unflowered canes (111, 116).

Maturation and Juice quality

Rainfall at the time of ripening affects sucrose content adversely by inducing sprouting (44). Lower minimum temperature and fall in humidity during flowering period are conducive to improvement in sucrose (79). Canes ripen earlier under swampy conditions (83). Time of planting is an important factor effecting the ripening period of cane (49). Heavy nitrogen manuring delays maturity and lowers quality of juice (49, 60, 117). Phosphate tends to hasten ripening and improve juice quality (65, 79). Repeated sprays of boron have likewise been reported to induce early maturity (17). Low hydration of tissue is associated with maturity (57). Under the sub-tropical North Indian conditions, sucrose content of juice steadily increases up to March-April irrespective of varieties, sowing dates, nitrogen and water levels (15, 20, 23). Atmospheric humidity, rather than temperature appears to influence initiation of inversion (118).

In the tropical South, bi-modal ripening curves with maxima during the cool season and minima during the warm season have been observed, growth being at the lowest ebb in the former when more sugar is available for storage (119). The general effect of irrigation appears to be an increase in sucrose per cent which is, however, not maintained after a certain limit. With the number of irrigations approaching the optimum, sucrose shows a declining trend (18-20, 82, 120). An inverse relationship between sucrose content and tissue hydration is indicated under all conditions irrespective of soil, culture and variety (57, 121). Top sett planting is invariably associated with superior juice quality (47). Sucrose formation is found to be favoured by a low N/P ratio (31). Varieties forming cavities early in their life show poor juice quality as compared to those forming cavities in late season (10).

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WE, THE FERTILIZERS...........*

By

HEMCHANDRA P. PATEL

Dear Farmer,

We are pleased to introduce ourselves to you and tell you some important things about ourselves. It will pay you, as a farmer, to know us well.

We are called the plant food elements and plants need us so that they can grow and reproduce. We are 15 in number, and our individual names are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, boron, copper, iron, zinc, manganese and molybdenum.

The first three of us are in the air as well as water and are available in abundance to plants, and you will never experience a shortage of them. The next three of us, nitrogen, phosphorus and potassium, are called major nutrients and are the backbone of plant life.

Calcium, magnesium and sulphur are called essential or secondary plant food elements and play an important role in the nutrition of plants.

Boron, copper, iron, zinc, manganese and molybdenum are the minor or trace elements and their deficiency in soils will affect the yield of your crops.

But we all work together and make your plants grow, develop and produce. We are all like a team of workers.

I AM NITROGEN

I am the '10' in 10-8-7 that you will find marked on your fertilizer bag. You will find me in many of the fertilizers such as ammonium sulphate, ammonium nitrate, sodium nitrate, potassium nitrate, urea, calcium, cynamide, oilcake as well as in the organic matter, farmyard manure and legume crops. Of course, you cannot see or smell me though I make up 4/5ths of the air you breathe in. In this form plants cannot use me because I am a gas. Either nature or man has to change me to a form which can be made use of by plants.

What do I do?

1. I give a dark green colour to plants.
2. I make crops grow fast.
3. Plants need and use a lot of me to build protein with.
4. I promote leaf, stem and fruit growths.
5. I improve the quality of leafy crops.
6. I act as a feed to micro-organisms during their decomposition of organic matter.

If there is my deficiency,

1. Crops will grow slowly;
2. There will be a sickly yellowish green colour;
3. Plants will start 'firing' or drying up on the centres of the bottom leaves.

What is my worth?

I am worth about the same per pound, no matter from where I come.

What else about me?

1. I am available to crops quickly.
2. I may be in 'nitrate' form or 'ammonia' form, or in both.
3. If I am applied in the 'ammonia' form, I soon change to the 'nitrate' form.
4. In 'ammonia' form, I do not move around in the soil very much.
5. I am very easily lost in my 'nitrate' form in sandy soils and go away very easily when the soil moisture takes me.

*Reproduced with permission from "Indian Farming".

I am Phosphorus

I am the middle '8' in your 10-8-7 or the middle figure in your fertilizer analysis. You can find me in superphosphate, rock phosphate, triple phosphate, bonemeal, guano, farmyard manure, basic slag, ammonium phosphate, meta phosphate and others.

What do I do?

1. I stimulate early root-growth.
2. I hasten maturity.
3. I play an important role in forming seed and fruit.
4. I improve the quality of the crop.
5. I give a rapid and vigorous start to plants.

If there is my deficiency,

1. There is slow growth and maturity;
2. There is low yield of grain, fruit and seed;
3. The leaves, stems and branches get purplish.

What is my worth?

1. I am worth about the same per pound, no matter from where I come.
2. If you want me for urgent use, buy me in an available form.
3. In some phosphate material, I am not in a readily available form.

What else about me?

1. I am very slowly available in acid soils.
2. I get fixed in heavy soils.
3. I do not show increased plant-growth as quickly as nitrogen does.
4. Very little of me is lost by leaching, but I do get lost by erosion.
5. I am necessary for plant growth, but plants do not use as much of me as they do of nitrogen and potash.
6. You call me phosphorus, but actually I am phosphoric acid (P_2O_5).

I am Potash

I am the last '7' in your 10-8-7 fertilizer mixture, or the last figure in your fertilizer analysis. You will find me in muriate of potash, sulphate of potash, manure salts, nitrate of potash, etc.

What do I do?

1. I increase plant vigour and disease-resisting capacity.
2. I make stalks stiffer.
3. I help plants make sugars and starch.
4. I help early roots to form and to grow.
5. I increase plumpness of the grains and seeds.
6. I impart winter hardiness to legumes and other crops.

If there is my deficiency,

1. Plants have short joints and make an unthrifty growth;
2. Many plants fall down before they are mature;
3. There is mottling, spotting, streaking or curbing of leaves starting on the lower levels;
4. Lower leaves are scorched or burnt on margins and tips;
5. In corns, grain and grasses, firing starts at the tips of the leaf and proceeds down from the edge, usually leaving the midrib green;
6. There is premature loss of leaves, and bolls get knotty in cotton.

What is my worth?

1. Like nitrogen and phosphorus, I am worth about the same per pound no matter from where I come.
2. I cost you less than nitrogen or phosphorus does.

What else about me?

1. I am readily available in the form you usually find me.
2. I am not lost by leaching as quickly as nitrogen is.
3. In sandy soils and subsoils, I am lost quickly.
4. My true name is potassium, but you call me potash (K_2O).
5. I may be in the soil in abundance, but sometimes I am in an insoluble silicate form.

I am Calcium

I am not expressed in the fertilizer formula. However, I am important. I am essential for plant-growth. You can find me in limestone, oyster shells, rock phosphate, bonemeal, superphosphate, gypsum etc.

What do I do?

1. I promote root formation and growth.
2. I improve the vigour and stiffness of straw.
3. I help the intake of other plant foods.
4. I neutralize poisonous secretions in the plant.
5. I am helpful in grain as well as seed production.

If there is my deficiency,

1. Young leaves remain folded;
2. There are light green bands along the margins of leaves;
3. The leaves have a wrinkled appearance;
4. Young leaves in the terminal bud become ' hooked ' in appearance and die back at the tips and along the margins.

What else about me?

1. Some fertilizers like calcium cynamide, calcium nitrate carry me.
2. I am found in most of the insoluble silicates.
3. I am found in low quantities in sandy soils.
4. I control the balance of equilibrium among other nutrients.
5. I am combined with the pectates, a cement-like material which occurs in the walls of plants.
6. Starch, sugar, and protein contents are greatly affected by my absence.

I am Magnesium

I am one of the secondary elements and very important for the plants. I am found in dolomitic lime, magnesium carbonate, magnesium sulphate, etc. When magnesium is guaranteed in a fertilizer analysis as 10-8-7-3, the last figure ' 3 ' is the percentage of water-soluble magnesium.

What do I do?

1. I am the basic metallic element in the chlorophyll—the green plant substance which captures the sun energy that is vital for life and growth.
2. I maintain a dark green colour of the plants.
3. I promote the formation of oils and fats.
4. I am the carrier of phosphoric acid in the plant.
5. I stimulate the growth of soil bacteria and enhance the nitrogen-fixing power of legumes.
6. I enable the plants to utilize other plant nutrients for healthy disease-resistant growth.
7. I activate the production and transport of carbohydrates and proteins in the growing plant.
8. I concentrate in the seed along with phosphorus.

If there is my deficiency,

1. There is loss of green colour which starts in the bottom leaves and gradually moves up the stalk. The veins remain green;
2. Leaves curve upwards along the margins;
3. The stalks are weak along with long, branched roots;
4. Series of yellowish-green, light yellow or white streaks are formed on the leaf.

What else about me?

1. I am the protoplasm of every plant cell.
2. I am found in an insoluble form on silicates like serpentine.

I am Sulphur

I am dug out from the mines in an elemental form. You can find me in gypsum, superphosphate, ammonium sulphate, potassium sulphate, etc. In the vicinity of the factories which burn coal, I am liberated into the atmosphere and returned to the soil in the rain-water.

What do I do?

1. I increase root growth.
2. I help maintain dark green colour.
3. I stimulate seed production.
4. Nodule formation on legumes is promoted by me.

If there is my deficiency,

1. Fruits are immature with light green colour;
2. Stalks are slender and short;
3. Young leaves are light green in colour and have lighter veins;
4. The leaves are spotted.

What else about me?

1. I am found in soils in the form of sulphates.
2. My available form is lost by leaching.
3. Under most conditions, I am supplied to the soils and eventually to the plants by fertilizers and rain.

And we are Boron, Copper, Iron, Manganese, Molybdenum and Zinc

Although required in relatively small quantities, our importance cannot be neglected. Unsatisfactory growth in many parts is traceable to the lack of one or more of our family. The range between our beneficial and detrimental use is so narrow that we should be utilized very carefully under expert advice. Overdose will be toxic to the plants. Some of us are available from the decomposed organic matter, the life of the soil.

If there is our deficiency,

1. I, boron, am deficient when there is cracked stem of celery, brown rot on cauliflower, yellow top in alfalfa, etc.;
2. My (molybdenum) exact function in plants is not understood by you, but I am helpful to the plants. I am deficient in acidic soils and my availability can be increased by liming the soils;
3. My (iron) need is shown by the pale-yellowish colour of foliage, in the presence of enough supply of nitrogen;
4. Citrus trees get die-back due to my (copper) deficiency, and onions and other vegetable crops are blasted due to my absence;
5. My (zinc) shortage is indicated by the white bud in maize and little leaf in fruit trees;
6. My (manganese) deficiency is shown by a pale green to yellow and red colour between the green veins of leaves of tomatoes, resinous spots on the leaves of citrus trees, grey specks on small grains and chlorosis on certain crops like soyabeans. We cannot forget our fast friend, organic matter which is really speaking the *life* of the soil. Our action on soil and plants is marvellous when the organic matter is associated with us. It is available from green manure, farmyard manure, crop residues, living organisms and other organic materials. The soil *humus*, the ultimate form of organic matter, is valuable for improving soil structure, water-holding capacity of soils, aeration, for supplying nitrogen and other members of our team.

We hope you have understood us well and will utilize us properly. In order to use us economically and judiciously, you must know what your soil needs and in what proportion. The need of your soil is determined by the following methods: (1) soil analysis, (2) external deficiency symptoms, (3) plant tissue tests, (4) field plot experiments and (5) biological tests of soil. You must note down the following points when using us and should put us in action accordingly.

1. Use us liberally but in the right proportion.
2. Use proper fertilizer for a particular crop under varying climatic and soil conditions.
3. Use us wisely as research has found us best.
4. Use us as advised by your agricultural department or by a technical person.

Let us help you in the following ways—

1. Build up an organic matter reserve in your soil for its improvement.
2. Let us cover your farm with a 'green blanket'.
3. Let us produce more and increase your yields in order to increase your prosperity and happiness.
4. Let us provide you better living standards, and so use us liberally and produce crops at a low cost per acre.
5. Let us grow green grass for pasturing your animals that give milk, meat and other essential things.
6. Let us help you in producing fibre, food and feed in abundance on which the nation's well-being depends.

Yours sincerely,

N-P-K-Ca-S-Mg-Cu-Bo-Fe-Mn-Mo & Zn.

FOREIGN CLIPPINGS

Sugarcane Pathology

ALL the virus diseases, reviewed in 35 volumes of Review of Applied Mycology are listed to gether (Hopkins, 1957). In sugarcane, there are seven of them namely chlorotic streak, dwarf, Fiji, mosaic, ratoon-stunting, sereh and streak. Three new diseases of this nature reported from India during recent years, are however, not given. They are (i) Leafy Tuft or Grassy Shoot (Sharma, S.L., 1951; Vasudeva, R. S., 1956), (ii) New Chlorotic disease (Anon, 1956) and (iii) Spike disease (Sharma, S. L., *et al.*, 1957). More information is forthcoming for old diseases caused by viruses. For the first time, Chlorotic Streak disease was reported from Bundaberg (Queensland) in Australia (Mungomery, R. W., 1956), The presence of mosaic virus has been demonstrated in the roots of sugarcane when six out of 100 *Sorghum* seedlings inoculated with extract of macerated roots of affected plant got infected (Adsuar, J., 1956). The streak disease has been reported to be transmitted by *Tomaspis liturata* var. *rufori-vulata* in Brazil (Franco, L., 1956). A histo-chemical method has been developed to show the presence of the virus causing ratoon-stunting disease, the identification of which in individual stalks was up till now very difficult. When three per cent H_2O_2 is applied for 10 to 15 seconds to longitudinal sections cut from the periphery of mature basal nodes of sugarcane, blotted off and followed by concentrated HCL, a blue-green colour appears after 20 to 30 seconds at leaf-scar level in the tissues around vascular bundles in healthy cane. In that affected by ratoon-stunting disease, this does not occur or the colour is limited to one or two bundles (Farrar, L. L., 1957). The disease has been reported for the first time from Jamaica (1955) and Brazil (Veiga, F. M., 1956).

Under conditions of natural infection the period of greatest susceptibility to red rot was 15 to 17 months after planting in Mauritius followed by one of resistance until 21-22 months when the ultimate break-down of the cane tissues occurs (Farrar, L. L., 1956).

Downy mildew caused by *Sclerospora sacchari* was again reported from Bundaberg (Queensland) in Australia on Vesta, P.O.J. 2878 and Q 50 (Steindl, D. R. L., 1956).

New diseases due to fungi also were reported. Leaf blast and black stripe disease caused respectively by *Didymosphaeria taiwanensis* and *Cercospora atrofiliformis* (both new species) are reported from Formosa (Yen, W. Y. *et al.*, 1957a and b).

Sugarcane seedlings were found attacked by *Helminothosporium sacchari* which is the causal agent of " eye spot " disease of sugarcane. It killed up to 75 per cent of seedlings raised from fluff under humid conditions. It has therefore been suggested that the eye-spot disease of sugarcane should be called " eye spot and seedling blight ". (Loveless, A. R. and Smith, C. E. M., 1956).—S. L. SHARMA, Sugarcane Research Institute, Pusa, Bihar.

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Miscellany

THE PUGALUR FURNACE

THE local furnace commonly used along the Cauvery valley in the Districts of Coimbatore, Salem, and Tiruchirappalli of Madras State is called Pugalur furnace. This is a large-size single-pan furnace capable of boiling large quantities of cane juice within a short period. It is a common sight to find mobile units consisting of a power crusher, and oil engine, a pan and accessories with ten specially trained persons moving from place to place and crushing about 10 to 12 tons of canes and converting them into 1 to $1\frac{1}{4}$ ton of *gur* in 15 hours.

Description of the furnace: The furnace is conical in shape with the sides converging slightly towards the month (Fig. 1). The top and bottom diameters of the furnace are 8'-9" and 12'-0" respectively. The depth of the furnace is 6'-0". It is constructed with bricks and earth. It is provided with a feed-hole in the front measuring 3'9" in width and 4'9" in height with an arch at the top. It also serves as a hole for removing ash. On both sides of the arch there is a support wall 8' in length and 6'9" in height. In between the support wall and straight above the arch there is the 'smoke preventive wall', measuring 14' in length and 3' in height. This prevents the ash, smoke and other dirt from the furnace falling into the juice-boiling pan. The entire construction of the furnace, namely the lining wall, support wall, smoke-preventive wall (except the feed-hole arch) is constructed with single brick and the rest of the portion filled up with earth. The feed-hole arch and 2' length of the support wall on either side are constructed with $1\frac{1}{4}$' bricks to ensure strength.

Cost of construction: The materials required are 3,000 sundried bricks and 1,000 burnt bricks and ten cartloads of earth. One mason and two men can construct the furnace in three days, and this time is required for proper setting of the furnace. It is usually roofed with a thatched shed which gives protection from sun and rain and provides accommodation for the accessories used and labour engaged in the working of the unit.

Cost

		Rs.
1.	3,000 sundried bricks @ Rs. 5/- per 1,000	15 00
2.	1,000 burnt bricks @ Rs. 15/- per 1,000	15 00
3.	Ten cart-loads of earth at Rs. 1·50 nP. per cart load	15 00
4.	Labour, 1 mason at Rs. 2·50 per day and 2 men assisting at Rs. 1·25 nP. per day for 3 days	15 00
	Cost of furnace ..	60 00
5.	Roofing with thatched shed measuring 18'×33"	90 00
	Cost of furnace and shed ..	150 00

Working of the furnace: A single round and flat-bottom pan is used. The top and bottom diameters of the pan are 8'9" and 12' respectively and vertical height is 1' 2". The pan is made of thin iron sheets, 1/16" thick in the sides and 1/18" thick at the bottom. It is provided with four or six small rings at the sides for handling the pan.

Juice boiling capacity: The furnace can boil 18 maunds (about 1,500 lbs.) of juice in 90 minutes and ten charges are taken in a day, i.e. the furnace pan deal with juice of 300 maunds of cane in a period of 15 hours.

Fuel feeding and consumption: The dried bagasse is bundled with cane trash weighing about a maund and fed through the feed hole at intervals of about ten minutes with the help of an iron fork attached to a long bamboo. Feeding the furnace is regulated well in advance of striking point so as to prevent any possible charging. At the striking points the pan is removed with the help of six men and contents emptied into a long wooden trough measuring 10' 0"×2' 0"×0·10". To facilitate easy lifting of the pan at the striking point a pan-lifting device with a pulley arrangement is provided in a few centres. The pan is then immediately placed on the furnace for the next charge.

The fuel consumption of the furnace works out to 45 per cent. The furnace is simple and cheap in construction and compares favourably with any of the single pan furnaces used in the country, as it is capable of boiling 12 maunds of juice per hour.—*Sugarcane Research Station, Cuddalore, Madras.*

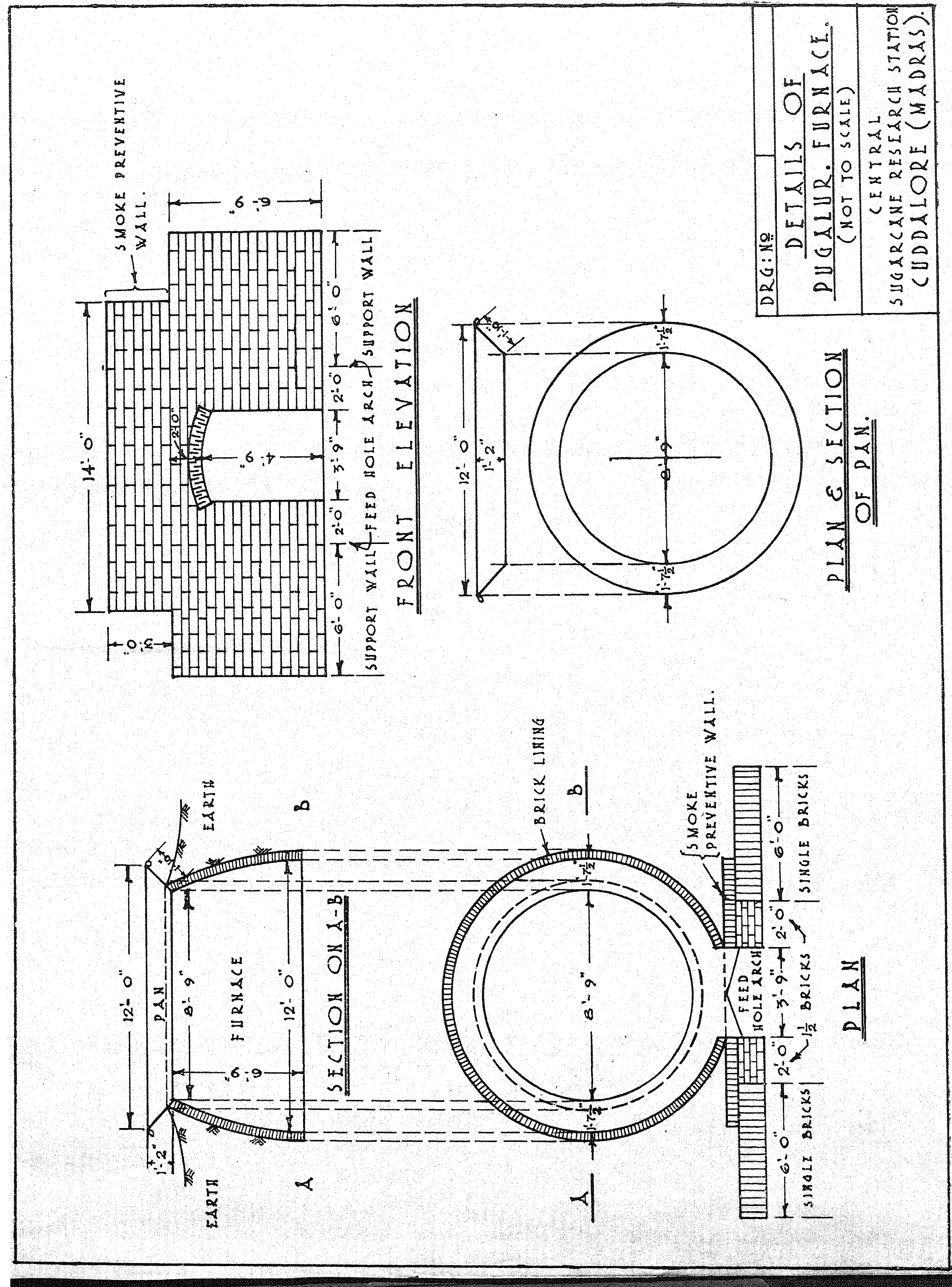
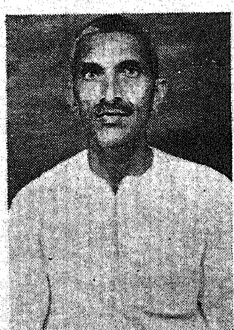


FIG. 1. Details of Pugalur furnace. (not to scale).

ALL-INDIA SUGARCANE CROP COMPETITIONS, 1956-57

THE Indian Central Sugarcane Committee initiated an All-India Sugarcane Crop Competition Scheme during 1956-57 as a Central Co-ordinating Scheme for creating lively interest in the cane growing community for higher production of sugarcane and providing further scope for the development of the crop. About 45 Competitors from the States of U.P., Bihar and Punjab in the Northern region and from Bombay, Madras and Andhra Pradesh in the Southern region participated in the Scheme during 1956-57. The Central Sugarcane Competition Sub-Committee, which is a standing Committee under the Indian Central Sugarcane Committee for guiding and supervising the All-India Cane Competitions in the different States, scrutinised the results of the Competitions in April, 1958 and decided on the award of three prizes in each region to the following cane growers:—

NORTHERN REGION

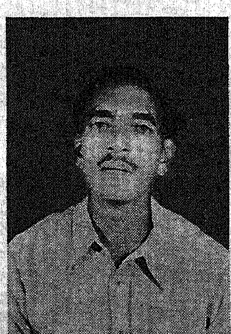


Shri Jagdeo Chaudhri
Distt. Basti, U.P.
Yield/Acre—1,663 Mds. (61·086 tons)
First prize winner—Prize Rs. 2,500/-

Shri Prithvi Nath
Distt. Meerut, U.P.
Yield/Acre—1,539·43 Mds. (56·473 tons)
Second prize winner—Prize Rs. 1,000/-

Shri Bishnu Sah
Distt. Champaran, Bihar
Yield/Acre—1,527·60 Mds. (56·099 tons)
Third prize winner—Prize Rs. 500/-

SOUTHERN REGION



Shri Yellamanchili Venkatachalam
Distt. Krishna, Andhra Pradesh
Yield/Acre—3,130·30 Mds. (115·00 tons)
First prize winner—Prize Rs. 2,500/-

Shri M. Sathi Raju
Distt. East Godavari, Andhra Pradesh
Yield/Acre—3,087·72 Mds. (113·418 tons)
Second prize winner—Prize Rs. 1,000/-

Shri T. Konda Reddiar
Distt. South Arcot, Madras
Yield/Acre—3,043·40 Mds. (111·791 tons)
Third prize winner—Prize Rs. 500/-

The Scheme has continued during 1957-58 and the Indian Central Sugarcane Committee has sanctioned it for the duration of the Second Five Year Plan.

Book Reviews

The Indian Sugar Industry (1956-57) Annual. Editor: M. P. Gandhi. Published by M. P. Gandhi & Co., Nanabhay Mansion, Sir P. M. Road, Bombay-1; pp. 350; price Rs. 6/-; V.P.P. Rs. 7·00/Sh.12.

Shri Gandhi's "Indian Sugar Industry Annual" has come to be looked upon as the standard reference work on Sugar, the major industry of India. The latest edition maintains well the reputation of previous ones. Up-to-date statistics having a bearing on the Sugar and Sugarcane industry are given in the Statistical Section, comprising 91 Tables. Topics like sugarcane price, cess, sugar imports and import duties and legislation are dealt with in the General Section. The Review Section is devoted to subjects like Sugarcane Production, By-products of the sugar industry, Palm-Gur, Sugar Exports and Sugar Consumption. The volume is rounded off with a Statewise review of the industry and a survey of the world sugar situation. On the whole, this moderately-priced publication should prove useful to all connected with the varied aspects of Sugar and Sugarcane industry.—P.K.

Cotton Atlas of India (1957). Published by the Secretary, Indian Central Cotton Committee, 14, Nicol Road, Ballard Estate, Bombay-1.

The Indian Central Cotton Committee deserves to be congratulated on the publication of a "Cotton Atlas" embodying comprehensive information in charts, maps and graphs, depicting various aspects of Indian cotton. It is a unique publication and perhaps the only one of its kind so far published. Though agriculture is an integrated science dealing with different crops and conditions, it is this pointed focus on individual commodities and crops that has paid high dividends in this country.

The Indian Central Cotton Committee, since its inception in 1921, has been devoting its undivided attention to the improvement and development of Indian cotton. The Committee has on different occasions during the last two Wars and after the partition met the various crises in a fitting manner and helped the cotton growers to tide over difficult conditions and vicissitudes. It is, therefore fitting that this pioneer body should have produced for visual instruction and general information a complete account of Indian Cotton, bringing home to laymen as well as to scientific investigators, the variations that occur in different parts of the country, in a simple, effective and impressive manner. The value of the publication is enhanced by the inclusion of up-to-date statistical data alongside the various illustrations.

The size of the Atlas is 13" × 10", printed on white art paper, with rexine cover, and containing 100 pages. It is priced Rs. 15/-.